Saskatchewan
Research Council

POTENTIAL FOR DEVELOPMENT OF A CRAYFISH INDUSTRY IN SASKATCHEWAN

by

W.W. Sawchyn

SRC Technical Report No. 184

Publication E-901-3-B-86 March, 1986

POTENTIAL FOR DEVELOPMENT OF A CRAYFISH INDUSTRY IN SASKATCHEWAN

by

W.W. Sawchyn

Prepared For:

Canada Department of Fisheries and Oceans
Under Supply and Services Canada
Contract No. OSF85-00026

SRC Technical Report No. 184

SRC Publication No. E-901-3-B-86

March, 1986

EXECUTIVE SUMMARY

This study was initiated in anticipation of developing a new resource based industry and new export market opportunities for Saskatchewan crayfish. A survey of crayfish populations was undertaken in twelve preselected sites distributed throughout the province to determine whether crayfish of suitable size and numbers for an export industry were available. The survey determined that lakes in southern Saskatchewan were the most promising sources of crayfish with respect to both size and numbers. None of the sites in the province provided significant numbers of specimens exceeding 9 cm, considered the minimum requirement for export. Substantial numbers were found in the 7.5 to 9.0 cm size range corresponding to Louisiana grown crayfish. These were generally distributed in the southern part of the province. The crayfish sampled were well within acceptable limits with respect to pesticide residues and metals in the edible flesh.

Bulk samples of crayfish were obtained for processing from lakes in the Qu'Appelle drainage system. Crayfish were collected by hand. They did not respond well to any of a variety of trapping methods tried. The ideal time for harvesting crayfish is the month of August. By then egg-bearing females are no longer present and most overwintered crayfish have moulted and have clean exoskeletons.

Crayfish can be temporarily stored in tanks at the lake

shore in preparation for processing. They can be transported live on ice and held in this manner for several days. Preparation of crayfish using Scandinavian techniques provides an attractive, tasty product. Long term storage of prepared crayfish can be achieved by vacuum packaging and freezing. Frozen crayfish are prepared by boiling or microwave heating.

Test marketing of Saskatchewan crayfish in Scandinavian countries revealed that they are not acceptable because of their small size. On the basis of prices offered for Louisiana crayfish it is doubtful if Saskatchewan crayfish products could be competive even if size were not an issue. A test of local markets showed a small amount of interest. A considerable amount of promotion and consumer education would be required to develop a local market in excess of about 500 kg. A retail price of about $11.00/kg could be expected, providing a return to the producer of about $5.00 - $6.00/kg.

Significant local market penetration would require development of efficient harvesting techniques, and an evaluation of intensive harvesting on crayfish populations.

ACKNOWLEDGEMENTS

The Saskatchewan Research Council (SRC) takes this opportunity to thank Supply and Services Canada and Fisheries and Oceans Canada for providing funds for the study. We thank our colleagues, Mr. J. Hnatiuk, Saskatchewan Tourism and Small Business, Mr. A. Wong, Arbokem Inc. and Messrs. D. Iredale and C. McKay, Fisheries and Oceans Canada for their active participation in the project and their financial and technical support.

Appreciation is extended to Messrs. D. Elsasser and, B. Wiens and SRC technical assistants, D. Richert and B. Paquin for undertaking the fieldwork for the study. We thank Dr. A. McCurdy, University of Saskatchewan, Department of Applied Microbiology and Food Science and M. Chen, Fisheries Branch, Saskatchewan Parks and Renewable Resources for making available processing and storage facilities for the study.

Special thanks are extended to Mr. B. Zuk, of the Saskatchewan Research Council for his active involvement in the study in particular the processing and marketing phases, to Messrs. M. Mellinger and W. Ross for their assistance with the statistical methods, and to Miss D. Diduck for her role in the preparation and typing of the final report.

TABLE OF CONTENTS

	Page
EXECUTIVE SUMMARY	i
ACKNOWLEDGEMENTS	iii
LIST OF TABLES	vi
LIST OF FIGURES	vii
1 INTRODUCTION	1
2 RATIONALE AND STUDY OBJECTIVES	3
3 METHODS	5
3.1 **Stage I** - Preliminary Population Survey and Sampling Site Selection	5
3.2 **Stage II** - Bulk Sampling, Product Preparation and Market Assessment	8
4 RESULTS AND DISCUSSION	11
4.1 **Stage I** - Preliminary Population Survey and Sampling Site Selection	11
4.1.1 Site Description	11
4.1.2 Species Abundance	17
4.1.3 Species Composition and Sex Ratio	24
4.1.4 Size Distribution of Crayfish Populations in the Survey Lakes	32
4.1.5 Body Proportions of Crayfish in Various Lakes	34
4.1.6 Chemical Analyses of Edible Flesh	36
4.1.7 Physical and Chemical Profile of Sampling Sites	40
4.1.8 Significance of Crayfish as Food for Fish	40
4.2 **Stage II** - Bulk Sampling, Processing and Market Assessment	43
4.2.1 Bulk Sampling	44
4.2.2 Processing	48
4.2.3 Market Assessment	49
4.2.3.1 Scandinavian Markets	49
4.2.3.2 Local Markets	52
5 SUMMARY AND CONCLUSIONS	55
5.1 **Stage I** - Preliminary Population Survey and Sampling Site Selection	55

TABLE OF CONTENTS (Continued)

Page

5.2 Stage II - Bulk Sampling, Product Preparation and Market Assessment 56

6 REFERENCES 59

APPENDIX I I-1

APPENDIX II II-1

APPENDIX III III-1

LIST OF TABLES

Table		Page
1	Estimated Abundance of Crayfish Captured by Beach Seine	19
2	Estimated Abundance of Crayfish Captured by Electrofishing	20
3	Sex and Maturity of Crayfish Caught in Various Lakes in Saskatchewan	25
4	Minimum and Maximum Total Lengths of Berried Females Caught in Various Lakes in Saskatchewan	28
5	Proportions of Crayfish Populations Exceeding 7.5 and 9.0 cm Total Body Length	33
6	Summary of Comparison of Total Length vs Tail Lengths in Male and Female Crayfish from Ten Sampling Locations	35
7	Chemical Analyses of Edible Tissue from Crayfish from Katepwa Lake	38
8	Tolerances for a Variety of Compounds Pertinent to Importation of Fish Products for Finland, Sweden and the United States	39
9	Physical and Chemical Profile of Sampling Sites	41
10	Proportion of Crayfish in Stomach Contents of Fish in the Surveyed Lakes	42

LIST OF FIGURES

Figure		Page
1	Crayfish Sampling Locations	7
2	Size Distribution of Crayfish Populations in Surveyed Lakes in Saskatchewan	29
3	Processed Crayfish Showing: A. Large *O. virilis* Male; B. Tray of Crayfish Ready for Vacuum Packing	50

1 INTRODUCTION

A feasibility study into the potential for developing a crayfish industry in Saskatchewan was conceived in recognition of the presence of large numbers of crayfish in the province, the absence of any users of this resource, and the presence of a potentially large export market for crayfish and crayfish products. The study was further stimulated by inquiries from a consulting company with direct connections with Scandinavian markets, prime users of crayfish, and an interest in developing the resource.

This study was preceded by a literature review on crayfish (Sawchyn 1985) which identified a broad range of information relevant to Canadian crayfish and the development of a crayfish industry in Saskatchewan. The information contained in the literature review served to provide direction for this study. Because of its thorough treatment in the earlier report the crayfish literature will not be a part of this document. Reference will be made as necessary to the earlier report.

The study was undertaken for the Department of Fisheries and Oceans jointly by three agencies. The Saskatchewan Research Council, as prime contractor, assumed overall responsibility for the project. The Saskatchewan Department of Tourism and Small Business, with an interest in economic and resource development in Saskatchewan was responsible for Stage II of sampling in northern Saskatchewan. Arbokem In-

corporated, a Montreal based consulting company provided technical and logistics support for processing and export test marketing.

2 RATIONALE AND STUDY OBJECTIVES

Crayfish have been recognized to have a widespread distribution in Canada (Crocker and Barr 1971), but because of their low economic importance have received little more than token acknowledgement of their presence. In Saskatchewan they are known to occur in most lakes and streams at least as far north as the Churchill River.

Arbokem Incorporated identified a potential market for crayfish in Finland and Sweden who consume large quantities of crayfish as part of festive traditions in those countries. A fungal disease, introduced from central Europe has decimated the native crayfish populations and has forced these countries to import crayfish in order to maintain their tradition. At present Sweden alone imports approximately 2000 tonnes annually. Imports are primarily from Turkey which is experiencing reduction in size and numbers because of overfishing and water pollution. These events have caused these countries to explore other sources.

Development of a crayfish industry in Saskatchewan in response to this export market would provide economic benefits through development of previously untapped resources and would offer a viable alternative to a declining inland fisheries industry.

In order to assess the feasibiity of developing a crayfish industry in Saskatchewan it was necessary to define, at least in a preliminary manner, the available crayfish re-

source with respect to both numbers and individuals and size, and to obtain data on harvesting, processing and marketing.

3 METHODS

The feasibility study into the potential for development of a crayfish industry in Saskatchewan was undertaken in two stages. The first stage included a crayfish population survey of twelve preselected water bodies representative of four geographic areas of the province:

1) Southern Agricultural Region
2) Southern Boreal Region
3) Limestone Region
4) Northern Precambrian Region

The second stage included attempts to collect a bulk sample of approximately 6000 crayfish from each of two locations identified in Stage I for purposes of preparing a product suitable for testing the consumer market. The product was then test marketed in Finland and Sweden and on the local market in Saskatoon, Saskatchewan.

3.1 STAGE I - Preliminary Population Survey and Sampling Site Selection

The selection of sampling sites in the four geographic regions of Saskatchewan was necessary in order to establish broad geographic criteria which could be used to identify suitable crayfish habitat, thereby providing a general basis for estimating the resource in the province.

Lakes in the Southern Agricultural Region of Saskatchewan are known to contain relatively large crayfish in abundance. The water bodies selected in this region included

Katepwa Lake and Last Mountain Lake in the Qu'Appelle River drainage and the South Saskatchewan River immediately downstream of Lake Diefenbaker (Figure 1). Lakes of the Parkland or Southern Boreal Region included Candle Lake, McBride Lake and a site in the Cumberland House area. The Limestone Region was chosen to determine whether lakes which have a high calcium content might be more suitable for crayfish production. Sites selected in the Limestone Region included Pinehouse Lake, Limestone Lake and the Nipekamew River (Figure 1).

The most economically depressed area which would benefit from a new resource based industry includes the Northern Precambrian Region. The three sites chosen in this region include Buffalo Narrows, Nemeiben Lake and the Churchill River at Otter Rapids.

Two methods of crayfish sampling were employed. Each was designed to obtain as complete a population profile as possible. Rocky areas in shallow water (1 m or less) were chosen for electrofishing. Sandy beach areas were sampled with a beach seine. Both methods provided a representative sample of the life stages of crayfish available in these habitats. Electrofishing was carried out during daylight hours. Seining was undertaken after dark when crayfish emerged from their hiding places to forage in the shallow water. In addition, crayfish were hand picked from the shallow water at night with the aid of a lantern.

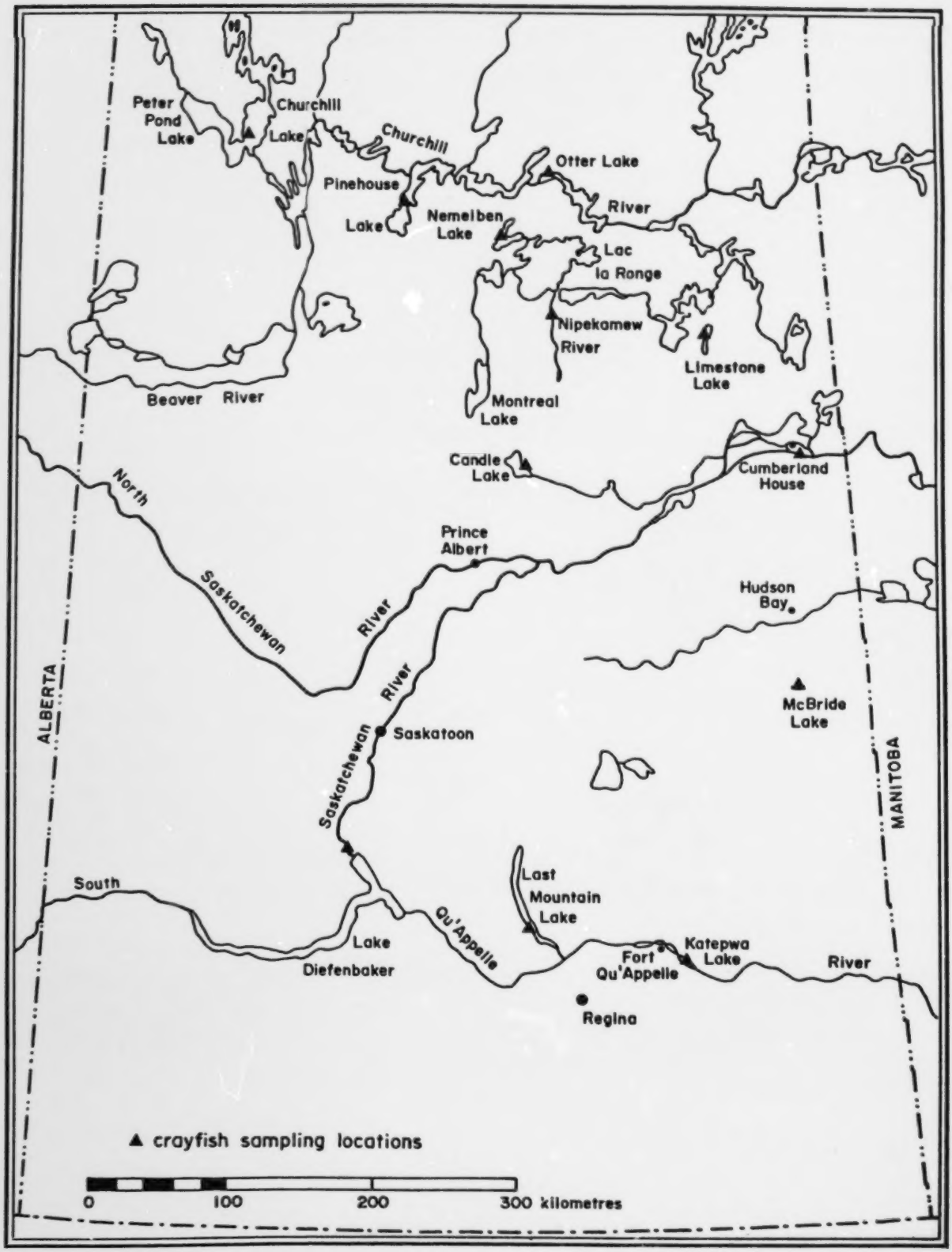


Figure 1. Crayfish Sampling Locations.

Samples of crayfish caught were enumerated, sexed and measured in the field. Measurements included total length, carapace length and abdomen length. Samples were retained for species confirmation and an assessment of edible flesh relative to total biomass.

Areas of habitat sampled were estimated to provide a measure of population density. Samples of larger crayfish were retained for chemical analysis with the intention that analyses would be carried out only on those lakes whose populations showed potential for bulk sampling and commercial harvest. Chemical analyses included arsenic, cadmium, copper, lead, zinc and organochlorines in the edible portions of the crayfish.

In addition to the crayfish collection, each site visit included collection of physical data such as water temperature, dissolved oxygen and specific conductivity, and a water sample for the determination of total dissolved solids and calcium.

3.2 STAGE II - Bulk Sampling, Product Preparation and Market Assessment

One of the objectives of the first phase of the study was to identify two locations (one in southern Saskatchewan and one in the north) where samples of approximately 6000 large crayfish could be obtained for processing in preparation for a market assessment. Katepwa Lake was selected as the collection site in southern Saskatchewan. McBride Lake

in the north served as the best sampling site with respect to numbers, however, none of the northern sites sampled provided specimens of a size that would approach market standards. The Lac la Ronge area was selected for bulk sampling primarily as a matter of convenience.

Arrangements were made to have crayfish bulk sampling done in southern Saskatchewan by Mr. Doug Elsasser, a local resident, and the only commercial fishing licence holder for crayfish in the province. In northern Saskatchewan, Brian Wiens, an employee of Mr. Jean Poirier, undertook the sampling under the direction of Saskatchewan Tourism and Small Business.

A variety of collecting methods were used for bulk sampling ranging from traps made from galvanized chicken wire, modified minnow traps and traps patterned after the Scandinavian Evo trap, to electrofishing, beach seining and hand picking. Since the object of this phase of the project was to get as many marketable crayfish as possible the trapping efficiencies of various methods were not quantified accurately. Impressions of the efficiency of various traps were obtained.

Crayfish caught were stored at the lake in tanks through which a continuous flow of lake water was passed. When sufficient numbers were collected they were transported live to a central processing facility in a large livestock watering tank containing a layer of crushed ice covered with

newspapers.

Processing was undertaken at the facilities of the University of Saskatchewan, Department of Applied Microbiology and Food Sciences who had the cooking, vacuum packing and freezing facilities appropriate for the job. Processing followed prescribed recipes obtained from Finland (see Sawchyn 1985) which consisted of preparing a kettle of saturated brine using noniodized table salt. Several cubes of sugar are added to soften the shells. The brine was brought to a boil and a generous amount of fresh dill added. Crayfish were sorted and dead and dirty ones discarded. Live crayfish were dropped into the boiling brine and cooked for 9 minutes. They were then removed from the water, cooled to room temperature and arranged on food trays in 500 g quantities. They were then vacuum packed and blast frozen for more permanent storage.

Logistics for exporting crayfish to test markets in Finland were executed by Mr. Al Wong, President, Arbokem Incorporated. Samples were packed in dry ice and sent to their destinations by air freight. Local markets were tested by offering crayfish for sale to the public through three Saskatoon retail seafood outlets on either a consigned or presold basis on the condition that customer feedback be provided where possible.

4 RESULTS AND DISCUSSION

4.1 STAGE I - Preliminary Population Survey and Sampling Site Selection

4.1.1 Site Description

1) South Saskatchewan River

The field survey and crayfish habitat evaluation began on June 19, 1985. Three locations on the South Saskatchewan River downstream of Lake Diefenbaker were examined. The first site just 200 m downstream of the power canal at Lake Diefenbaker contained several small pools lined with broken rock and gravel. No crayfish were found nor were any reported by a local farmer who dives regularly in the area. A second similar site approximately 1.5 km downstream also produced no crayfish or evidence of crayfish. Finally, a third site was examined approximately 1 km upstream of the bridge at Outlook, Saskatchewan. The location contained mixed gravels and rocks with no vegetation, with both swift current and quiet eddies. No crayfish were found nor was there any evidence of crayfish skeletons.

2) Last Mountain Lake

Sampling equipment failure resulted in two trips to Last Mountain Lake in south central Saskatchewan. The first trip, taken June 20, was made to an area of Last Mountain Lake directly east of the town of Imperial. The habitat in this area consisted of mixed exposed rock set lightly into silt. The area was littered with evidence of a large cray-

fish population. No crayfish were caught at this site primarily because of equipment failure.

A second site on the lake was visited at Weetoo Beach near the village of Holdfast on the fifth of July. The areas sampled ranged from clean light sandy beaches to littoral zones consisting of large rocks and boulders. Seining, hand picking and electrofishing (depending on habitat) produced 211 crayfish in the period of sampling which extended from 2:30 a.m. to 6:30 a.m.

3) Katepwa Lake

Several sites on Katepwa Lake were examined as potential areas for crayfish harvest. Habitat at each site was basically quite similar - clean beaches with little or no vegetation to a depth of 1 m. Where vegetation occurred it was sparse, primarily patches of filamentous algae. Some of the shore areas consisted of rounded stones, but where these stones extended into the water they were 80-90% submerged in silt or sand with no places for crayfish to hide. The rounded submerged stones and sandy beaches made most of the area conducive to seining. A total of 105 crayfish were obtained in this manner from two sites. Both sites had large numbers of large male crayfish exoskeletons on the shore and in the shallow water. At least some of these were dead crayfish, others may have been cast skeletons from newly moulted specimens.

4) Candle Lake

Candle Lake was sampled during the night and early morning of June 24-25, 1985. A variety of littoral types were extensively sampled using seining, hand picking and electroshocking techniques. The habitats ranged from sandy beaches where seining was most effective to rocky areas where electrofishing was the only method which could be used.

Sample collections from rocky areas at Minowakau and Hayes Beaches produced only 33 crayfish. No crayfish were found in several other areas examined although windy conditions produced poor visibility at times.

5) Cumberland House

The second area sampled in the Southern Boreal Region included Cumberland Lake near its outflow into the Tearing River and the Saskatchewan River near Cumberland House. Sampling was carried out on June 25 and 26. Cumberland Lake near the Tearing River is typical low land with willow on shores and a littoral zone containing large irregular limestone rocks and extensive areas of Scirpus. The near shore areas contain gravel and sand but at depths greater than 1 m the bottom is very soft organic silt containing stands of submerged Potamogeton sp. Sampling for crayfish with the methods selected was almost impossible. Seining in the lake yielded only two crayfish.

Other areas were examined including the Tearing River, Bigstone River and the Saskatchewan River. The Tearing River was shallow, full of rapids, and of low visibility at the time of sampling. No crayfish were caught. Sampling at the mouth of the Bigstone River produced three crayfish in 50 m of seining. The survey crew was directed to some back eddies in the Saskatchewan River downstream of the ferry by the local Resource Officer. The habitat consisted of pools of water with a shoreline of exposed mud flats, occasional rocks with some Scirpus and Typha. The pool bottoms were of moderately firm grey-brown silt. One hundred and thirty-eight crayfish were seined from an area of 240 m^2.

6) McBride Lake

McBride Lake in east central Saskatchewan was visited on June 26 and 27. The lake is long and narrow with steeply sloping littoral zones. The shoreline is largely of broken or irregular rocks. Some weedy mud and sand bays are found near the ends of the lake. Only one beach was available for seining. Electrofishing was used to obtain samples from rocky areas. Seining and hand collecting yielded 70 crayfish. Another 154 specimens were collected using the electroshocker.

Some snorkelling was done in water ranging in depth from 1.5 to 2.5 m. No crayfish were seen at depths greater than 1.5 m.

7) Buffalo Narrows Area

Preselected sampling sites in the vicinity of Saskatchewan's Limestone Region included an unspecified site in the Buffalo Narrows area. The survey crew investigated three sites in this region on July 2 and 3. MacBeth Channel (about half way between Buffalo Narrows and Ile a la Crosse), Churchill Lake (two locations) and Peter Pond Lake at Niska Channel.

MacBeth Channel shores are characterized by piled rounded rocks and sparse clumps of willow and alder in flooded areas. Only four crayfish were caught. The second site, on Churchill Lake, characterized by a gently sloping shore made up of rocks, silt and mixed fine gravel yielded 36 crayfish from electrofishing in five different locations.

Very strong on shore winds prevented sampling on Peter Pond Lake. A limited amount of seining on a sandy weedy beach caught only two crayfish.

8) Pinehouse Lake

Pinehouse Lake was visited July 3 and 4, 1985. The shores of this lake are typically lined with unsorted rock. High water levels inundated normally exposed lichen covered rocks. Only one site was suitable for seining: six other sites were sampled by electrofishing. Extensive sampling produced only 29 crayfish.

9) Limestone Lake

Limestone Lake situated on Highway 106 in northeastern Saskatchewan was selected to determine whether lakes on dolomite deposits were preferred sites for crayfish. Extensive sampling by electroshocking in the broken limestone plates on July 8 produced no crayfish inspite of the fact that earlier surveys have noted the occurrence of crayfish in fish stomachs. An alternative site was selected on the Sturgeon-Weir River at Maligne Lake. Thirty-nine specimens were hand collected from among rocks near the shore of this lake.

10) Nipekamew River

A site on the Nipekamew River at the Highway 165 crossing south of Lac La Ronge was examined as a potential site for crayfish. The habitat proved to be unsuitable, consisting of shifting sand. There was no evidence of crayfish at this location.

11) Otter Lake

This site was the most northerly Precambrian Lake sampled. It is located near Otter Rapids on Highway 102 about 80 km north of La Ronge. The rocky shoreline proved to be generally unsuitable for seining. Electrofishing in five locations resulted in the collection of 144 specimens. The distribution of crayfish along the shore is obviously uneven with some sites yielding large numbers.

12) Nemeiben Lake

The final sampling site of the Stage I field survey was visited on July 11. Nemeiben Lake, approximately 30 km north of La Ronge is also typically Precambrian, extensive rocky shoreline of exposed bedrock. Five sites were electrofished resulting in the collection of 117 specimens.

In addition to this study a separate and more intensive survey was undertaken of seven lakes in the La Ronge area to assess the trapability of crayfish for commercial harvesting in the north (Wiens 1985, see Appendix I). The sites included:

1) The Montreal River - Lac La Ronge Area
2) Bigstone - Egg Lake Area
3) Mountain - Drope Lake Area
4) Nemeiben River - Lac La Ronge Area
5) Potato River - Lac La Ronge Area
6) Weyakwin - Montreal Lake Area
7) Besnard Lake Area

The study reports data from approximately 750 trap nights using a variety of traps, primarily modifications of minnow traps. The report is provided as Appendix I.

4.1.2 Species Abundance

Beach seining and electroshocking techniques were used to provide a sample of crayfish representative of all available size classes in the most efficient manner. In con-

trast, crayfish traps select only the larger crayfish allowing the smaller specimens to escape. Efficiency of traps is very low providing few specimens per unit effort. Results of beach seining and shocking are difficult to quantify. Efficiency is dependent upon location selected, time of day, substrate type, estimates of area sampled and the dedication of equipment operators. We are therefore only able to provide estimates of relative abundance suitable for determining whether a bulk sample could be obtained to complete Stage II of the study.

Table 1 provides a summary of the seining efforts. Generally, seining was most successful in the southern lakes where suitable beach areas were in abundance. For example, Katepwa Lake could be seined almost anywhere. Northern lakes with their rocky shoreline were less conducive to seining. Recoveries of crayfish by seining were low primarily because the sandy beach habitat is used by crayfish only for foraging at night and lacks the cover for daytime occupation.

The best recoveries by seining were obtained from Last Mountain Lake where 0.53 crayfish/m^3 were recovered during nighttime seining. The Saskatchewan River at Cumberland House yielded 0.29/m^2 and McBride Lake 0.13/m^2.

Estimated abundance of crayfish based on captures by electrofishing is shown in Table 2. Recoveries of crayfish per unit area were considerably higher using electrofishing

Table 1. Estimated Abundance of Crayfish Captured by Beach Seine.

Location	Habitat	Area Surveyed (m^2)	No. of Crayfish	No./m^2
Katepwa Lake - Sandy Beach	sand	840	48	0.06
Katepwa Lake - Public Beach	sand	980	57	0.06
Last Mountain Lake - Weetoo Beach	sand	200	106	0.53
Candle Lake - Sandy Bay	sand	300	0	0.00
Candle Lake - Minowakau Beach	sand	800	5	<0.01
Cumberland Lake	rocks, silt	800	5	<0.01
Saskatchewan River - at Cumberland House	silt, sand	480	138	0.29
McBride Lake	sand, gravel	550	71	0.13
Pinehouse Lake	sand, rock	240	2	<0.01

Table 2. Estimated Abundance of Crayfish Captured by Electrofishing.

Location	Habitat	Area Surveyed (m^2)	No. of Crayfish	No./m^2
Last Mountain Lake - Grandview Beach	rock	8	70	8.75
Last Mountain Lake - Weetoo Beach	rock	8	35	4.38
Candle Lake - East Torch River	rock	60	3	0.05
McBride Lake	rock	50	155	3.10
Churchill Lake - MacBeth Channel	rock	38	2	0.05
Churchill Lake - Site 1	rock, gravel	17	29	1.76
Churchill Lake - Site 2	rock, gravel	18	3	0.17
Churchill Lake - Site 3	rock, gravel	30	1	0.03
Churchill Lake - Site 4	rock, gravel	30	0	0.00
Pinehouse Lake - Site 1	rock	19	12	0.65
Pinehouse Lake - Site 2	rock	18	1	0.06

Table 2. (Continued)

Location	Habitat	Area Surveyed (m^2)	No. of Crayfish	No./m^2
Pinehouse Lake - Site 3	rock	53	0	0.00
Pinehouse Lake - Site 4	rock	15	0	0.00
Pinehouse Lake - Site 5	rock	15	0	0.00
Pinehouse Lake - Site 6	rock	33	25	0.76
Pinehouse Lake - Site 7	rock	38	0	0.00
Otter Lake - Site 1	rock	55	27	0.49
Otter Lake - Site 2	rock	8	13	1.66
Otter Lake - Site 3	rock	24	7	0.29
Otter Lake - Site 4	rock	12	11	0.92
Otter Lake - Site 5	rock	35	66	1.89
Otter Lake - Site 6	rock	20	31	1.58

Table 2. (Continued)

Location	Habitat	Area Surveyed (m^2)	No. of Crayfish	No./m^2
Nemeiben Lake - Site 1	rock	30	37	1.23
Nemeiben Lake - Site 2	rock	24	38	1.58
Nemeiben Lake - Site 3	rock	30	7	0.23
Nemeiben Lake - Site 4	rock	36	25	0.69

techniques primarily because sampling was carried out among rocks, typical habitat of crayfish. The numbers of crayfish actually caught and reported are 40 to 60% of the total population present. The remainder either escaped or were immobilized and fell among the rocks. After the initial response to the electric current, at least one-half hour must elapse before the crayfish are once again attracted. Recoveries by electrofishing once again showed Last Mountain Lake to be the most productive at $8.75/m^2$. McBride Lake yielded $3.1/m^2$. Northern lakes which could not be sampled by seining yielded as many as 1.76 in Churchill Lake and 1.9 in Otter Lake. Several of these lakes sampled in a variety of locations showed a wide range of abundance. As a result it is not possible to provide a quantitative estimate of crayfish populations based on habitat characteristics.

Sampling using both beach seining and electrofishing were restricted to areas shallower than 1.5 m. Skin diving was used in McBride Lake to confirm that few crayfish are found in areas beyond this depth.

On the basis of abundance it was recommended that Katepwa and Last Mountain Lakes be considered for obtaining a bulk sample for processing in southern Saskatchewan. McBride Lake and the Saskatchewan River at Cumberland Lake were most appropriate in central Saskatchewan. Otter Lake had the largest numbers in northern Saskatchewan.

Three sites, the South Saskatchewan River downstream of

Lake Diefenbaker, Limestone Lake and the Nipekamew River produced no crayfish.

4.1.3 Species Composition and Sex Ratio

Examination of male specimens retained from all collecting sites showed all of the individuals to be members of one species Orconectes virilis (Hagen). A wide range of colours was observed among the specimens from various locations. McBride Lake specimens in particular were a dark brown in contrast to the more typical greenish mottled appearance of other crayfish. This is probably related to water quality, in particular the high iron content of the water. The crayfish in the less transparent southern lakes tend to be lighter coloured.

A wide range of sex ratios was obtained (Table 3). For example, two sites sampled in Katepwa Lake yielded diametrically opposite sex ratios. Electrofishing tended to attract a higher proportion of females than beach seining supporting documented evidence that berried females tend to be more secretive. The limited survey data are insufficient to establish population sex ratios for any given lake.

Sampling began at the height of the reproductive period. Ninety percent of the females caught in Katepwa Lake on June 20 were berried (carrying eggs). Northern lakes sampled at later dates carried eggs which were close to hatching. The proportion of berried females was also lower

Table 3. Sex and Maturity of Crayfish Caught in Various Lakes in Saskatchewan.

Lake	Sampling Site	Date	Number Males	Number Females	Percent Berried Females
Katepwa	sandy beach	21.6.85	10	38	86.8
Katepwa	public beach	21.6.85	40	15	93.3
Last Mountain	Weetoo beach	5.7.85	73	139	42.4
Candle	Hayes beach (rocky shoreline)	24.6.85	27	6	33.3
Cumberland	from various small rocky islands	25.6.85	1	4	0.0
Saskatchewan River	just downstream from Cumberland House	26.6.85	98	39	23.1
McBride	electrofished on rocky shoreline	27.6.85	68	87	24.1
McBride	hand picked from beach	27.6.85	49	21	42.9
Churchill	rocky shoreline	2.7.85	22	14	42.9
Pinehouse	public beach (seine)	3.7.85	6	2	0.0
Pinehouse	rocky shorelines (electrofished)	4.7.85	17	4	25.0
Sturgeon-Weir River	rock outcrop (hand picked)	9.7.85	24	15	6.7

Table 3. (Continued)

Lake	Sampling Site	Date	Number Males	Number Females	Percent Berried Females
Otter	rocky shorelines (electrofished)	10.7.85	99	45	6.7
Nemeiben	rocky shorelines	11.7.85	69	49	6.1

(6%) suggesting that maternal care for eggs and young is completed by about mid July.

Measurements were made of berried females to determine the size at maturity in the lakes sampled (Table 4). Although sexual maturity in crayfish is known to occur in the second season of growth, this is not true for all crayfish. Large numbers of small nonberried females were caught in most lakes (Figure 2). The smallest berried female found had a body length of 4.6 cm. She was collected in McBride Lake. With the exception of Katepwa Lake minimum size of mature males ranged from 5 to 6 cm. In Katepwa Lake the smallest female caught was 7 cm. She was sexually mature. The maximum size of berried females conformed to the maximum size in the population, ranging from 5.4 cm in Nemeiben Lake to 8.9 cm in Katepwa Lake.

Sexual maturity in male crayfish is identified by the presence of Form I specimens (having functional copulatory appendages). A complicating factor is that Form I males may moult into Form II (having nonfunctional copulatory appendages) during the summer period when they are not sexually active, making them indistinguishable from males which have not matured for the first time. Sexing of the crayfish in the field did not include distinguishing Form I and Form II males. As a result no data are available on the size of males at sexual maturity.

Table 4. Minimum and Maximum Total Lengths of Berried Females Caught in Various Lakes in Saskatchewan.

Lake	Minimum (cm)	Maximum (cm)	No. of Crayfish
Candle	5.2	5.9	2
Saskatchewan River (at Cumberland House)	5.5	9.0	9
McBride	4.6	7.5	30
Churchill	5.4	6.3	6
Pinehouse	6.2	6.2	1
Sturgeon-Weir River	6.0	6.0	1
Otter	5.3	6.5	3
Nemeiben	5.1	5.4	3
Last Mountain	5.7	8.2	59
Katepwa	7.0	8.9	47

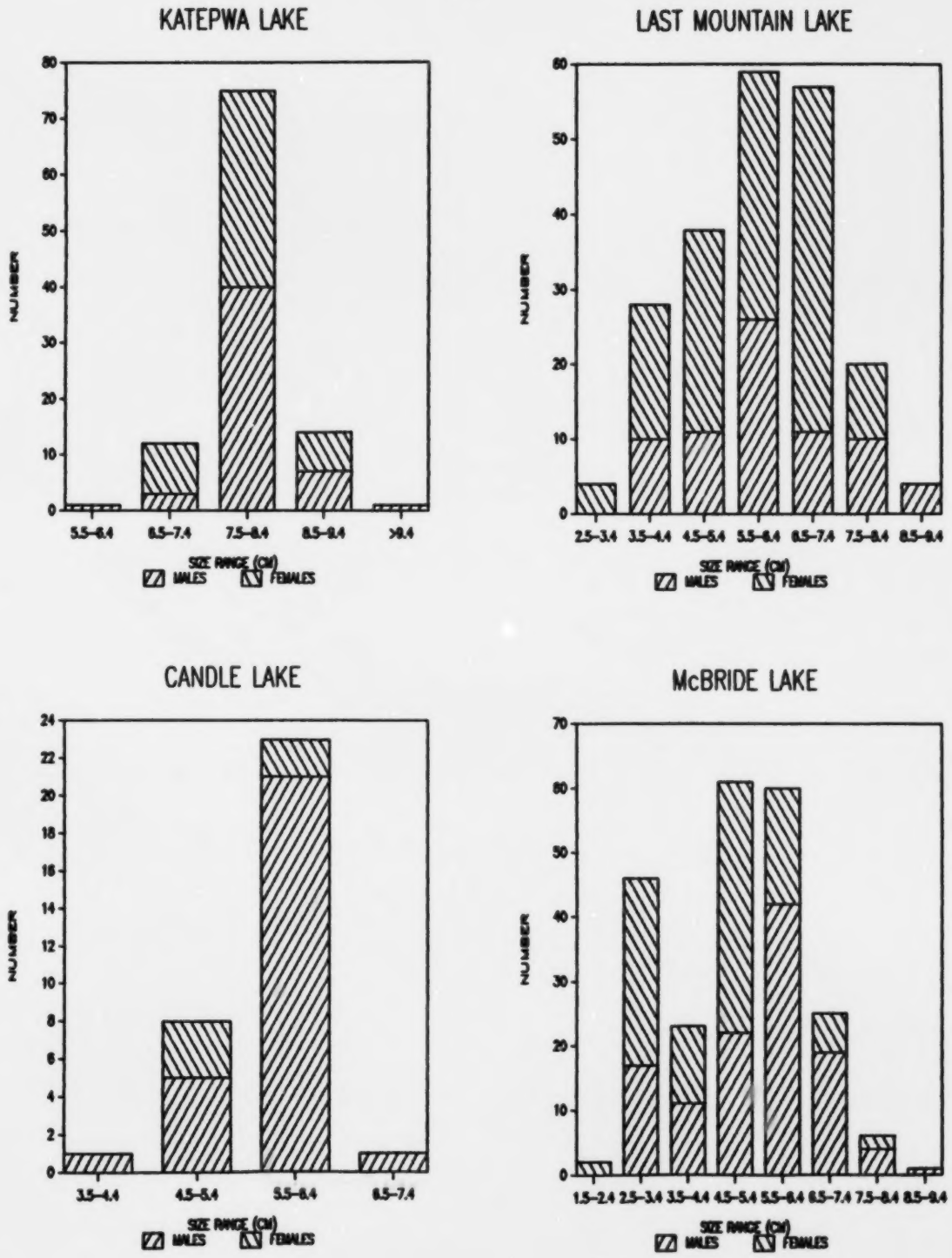


Figure 2. Size Distribution of Crayfish Populations in Surveyed Lakes in Saskatchewan.

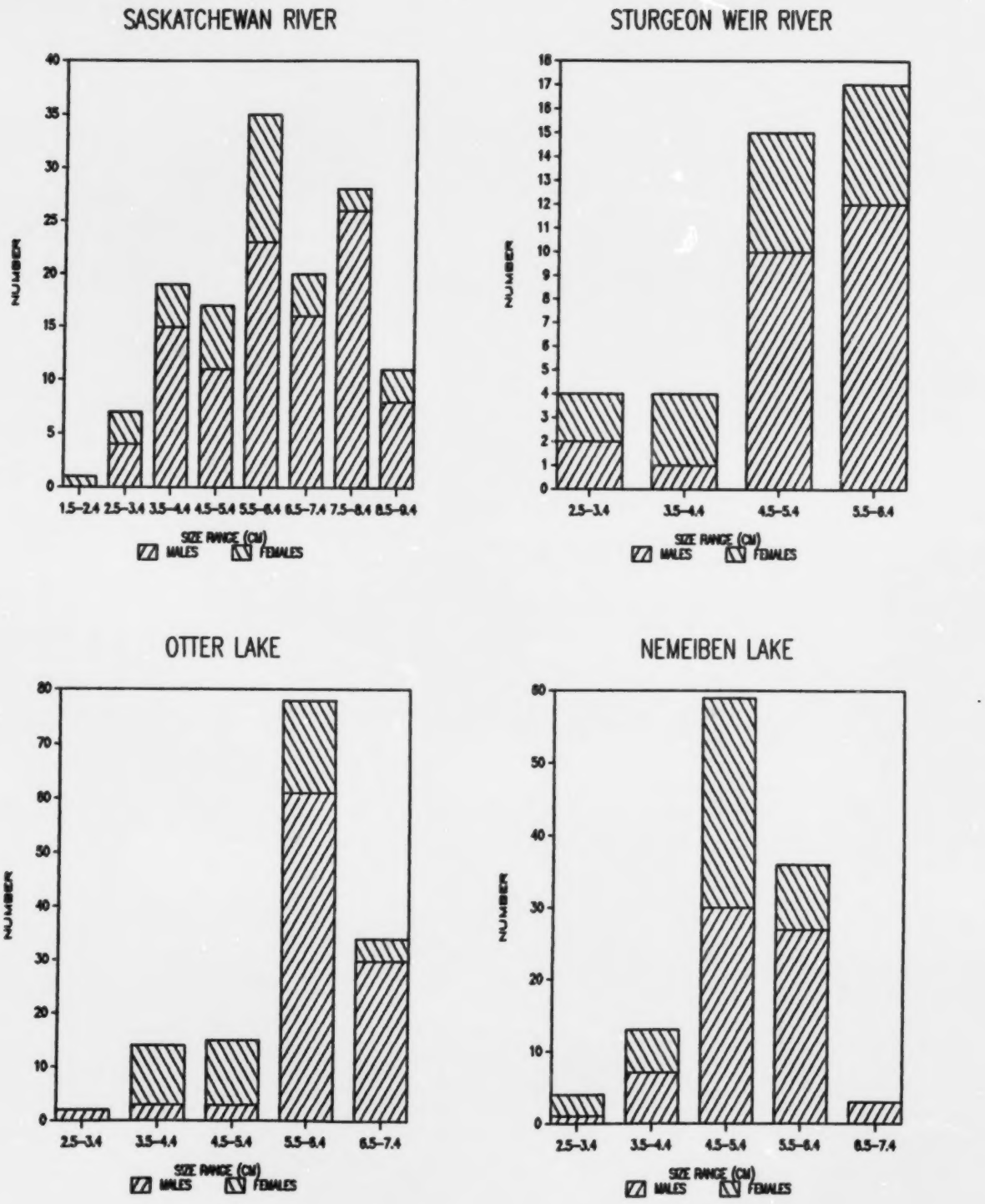
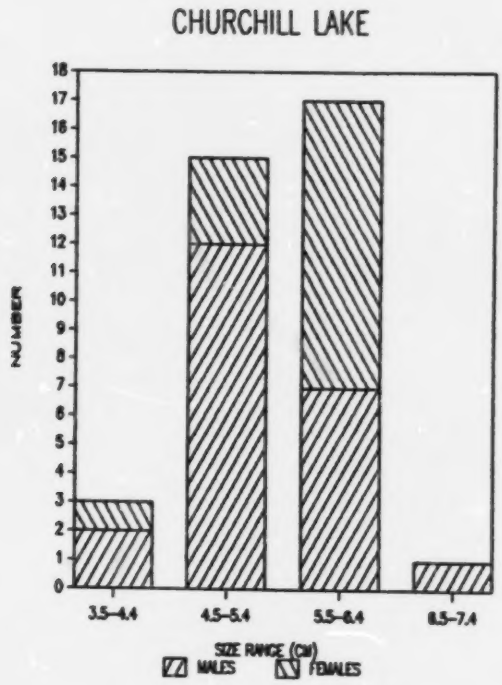


Figure 2 (Continued)



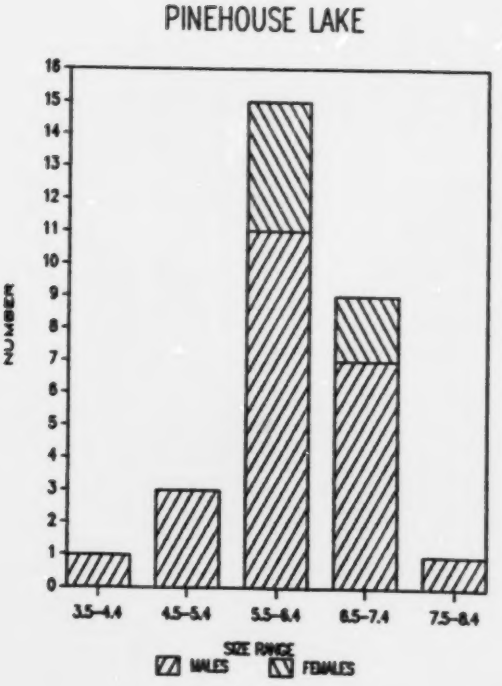


Figure 2 (Continued)

4.1.4 Size Distribution of Crayfish Populations in the Survey Lakes

A key purpose in the Phase I survey of lakes in Saskatchewan was to identify water bodies in which crayfish were large enough to warrant further collection for a market study. Crayfish are required to have a body length of 9 to 10 cm (tip of rostrum to end of tail) to meet import regulations of Sweden and Finland, respectively. Crayfish caught for domestic consumption in Louisiana range upwards from 7.2 cm (Huner, pers. comm.[1]). Specimens 8.5 cm in size are considered premium crayfish in Louisiana.

The size frequency distribution of crayfish caught in the survey lakes is shown in Figure 2. Table 5 was prepared showing the proportion of crayfish caught which were larger than 7.5 cm in total length, assuming this size to be the minimum acceptable size for domestic consumption. Also included are proportions of the population exceeding 9.0 cm which would be suitable for export.

Eighty-seven percent of the crayfish caught in Katepwa Lake were larger than 7.5 cm (total length), but only 2% exceeded 9 cm. Other locations with significant numbers of large crayfish were the Saskatchewan River at Cumberland House (28.3%) and Last Mountain Lake (11.4%). McBride and Pinehouse Lakes were the only other lakes which had any crayfish which met the selected size criteria.

[1] Dr. J.V. Huner, Southern University, Baton Rouge, Louisiana.

Table 5. Proportions of Crayfish Populations Exceeding 7.5 and 9.0 cm Total Body Length.

Lake	Date	Percent Crayfish >7.5 cm in Total Length	Percent Crayfish >9.0 cm in Total Length	Total Number
Katepwa	21.6.85	87.4	1.8	103
Candle	25.6.85	0.0	0.0	33
Saskatchewan River (at Cumberland House)	26.6.85	28.3	0.7	138
McBride	27.6.85	3.1	0.0	223
Churchill	2.7.85	0.0	0.0	36
Pinehouse	3/4.7.85	3.4	0.0	29
Last Mountain	5.7.85	11.4	0.5	210
Sturgeon-Weir River	9.7.85	0.0	0.0	40
Otter	10.7.85	0.0	0.0	144
Nemeiben	11.7.85	0.0	0.0	116

On the basis of the above observations none of the lakes surveyed would provide sufficient numbers of large crayfish to develop an export industry. On the basis of populations and crayfish size Katepwa Lake holds the greatest potential for crayfish harvesting with some possibilities for the Saskatchewan River and Last Mountain Lake. The northern lakes surveyed hold no potential for development of either an export or consumptive market based on whole crayfish.

4.1.5 Body Proportions of Crayfish in Various Lakes

Studies were undertaken to determine whether the edible "tail" portion was proportional to the thorax in all sizes of crayfish, i.e. does the "tail" remain relatively constant beyond a certain size.

Graphs were prepared of tail lengths relative to total body lengths for males and females at each sampling point (Appendix II). Linear regression analyses showed a high degree of correlation between tail length and total body length in both male and female crayfish (Table 6). Noted exceptions were the result of too few data points or too small a range in population sizes.

Analyses of covariance on the data from the ten lakes sampled (Appendix III) showed that sampling site has a strong effect on the relationship between tail length and total length, being expressed as both an additive effect and

Table 6. Summary of Comparison of Total Length vs Tail Length in Male and Female Crayfish from Ten Sampling Locations.

Lake	Sex	Number of Samples	Pearson Coefficient of Correlation	Line Slope
Katepwa	Male	52	0.555	0.239
	Female	53	0.814	0.271
Last Mountain	Male	74	0.982	0.350
	Female	136	0.946	0.373
Saskatchewan River	Male	100	0.979	0.358
	Female	38	0.980	0.340
Candle	Male	28	0.774	0.380
	Female	5	0.876	0.528
McBride	Male	120	0.963	0.340
	Female	102	0.974	0.364
Churchill	Male	22	0.953	0.350
	Female	14	0.920	0.400
Pinehouse	Male	23	0.946	0.362
	Female	6	0.743	0.246
Nemeiben	Male	69	0.891	0.321
	Female	48	0.879	0.369
Otter	Male	99	0.931	0.322
	Female	45	0.940	0.365
Sturgeon-Weir River	Male	24	0.918	0.338
	Female	15	0.990	0.364

an effect on the slope. These results are predictable from the observed differences in size of crayfish among lakes. Generally lakes with smaller crayfish show larger tails relative to total length. Katepwa Lake with the largest crayfish produced specimens with very short tail portions relative to total length. The lowest slope was obtained for females from Pinehouse Lake, however this is probably due to the low sample size.

Sex of the crayfish has a strong effect on the relationship between total length and tail length. Generally, females have larger tails relative to total size. Two exceptions were the Saskatchewan River at Cumberland House and Pinehouse Lake which produced males with larger tails. The results in both locations may have been biased by relatively low numbers of females caught.

4.1.6 Chemical Analyses of Edible Flesh

In the course of the survey, samples of crayfish were collected and frozen for chemical analyses of the edible flesh. At the outset it was understood that only those lakes showing potential for providing a bulk sample of marketable crayfish would be analysed. On the basis of the results provided, Katepwa Lake was the only location which met this criterion with respect to both crayfish numbers and size.

Chemical analyses of crayfish from Katepwa Lake were

undertaken at the Analytical Laboratory of the Saskatchewan Research Council. Parameters analysed included those which could potentially be a risk to consumer health and would be considered a hazard under the Fish Inspection Regulations. Parameters included were mercury, arsenic, cadmium, copper, lead, zinc and organochlorines.

The GLC organochlorine scan concentrated on the common insecticides and herbicides. Crayfish flesh was pooled from several specimens in order to obtain sufficient material for each group of analyses (approximately 5 g each). Results are presented on a wet weight basis.

The results of the analysis are provided in Table 7. By nature of the Qu'Appelle watershed with its extensive drainage from agricultural land and its sewage load from the cities of Regina and Moose Jaw one would expect the crayfish heavy metal and pesticide body burden to approach the worst case situation for Saskatchewan.

Table 8 provides a list of tolerance levels of a variety of compounds measured in imported fish products in Finland, Sweden and the United States, potential customers of Saskatchewan crayfish. Where comparisons are possible, the tolerance levels are generally at least an order of magnitude higher than the levels found in our study. On the basis of these comparisons contamination by metals or common organic compounds would not likely be a restrictive element in making our crayfish available to the export market.

Table 7. Chemical Analyses of Edible Tissue from Crayfish from Katepwa Lake (µg/g wet weight).

Trace Metals	
Mercury	<0.05
Arsenic	0.19
Cadmium	<0.05
Copper	6.2
Lead	<0.2
Zinc	19
Organochlorines	
Alpha-BHC	<0.01
Lindane	<0.01
Beta-BHC	<0.01
Heptachlor	<0.01
Aldrin	<0.01
Heptachlor Epoxide	<0.01
Dieldrin	<0.02
Endrin	<0.02
DDT (Total isomers)	<0.05
PCB's	<0.05
2,4-D	<0.1
2,4,5-T	<0.05

Table 8. Tolerances for a Variety of Compounds Pertinent to Importation of Fish Products for Finland, Sweden and the United States (From Department of Fisheries and Oceans).

	µg/g (dry weight)
Finland	
Histamine	100
Mercury	1.0
Arsenic	5.0
Lead	2.0
Tin	150
Cadmium	0.3 (Recommended)
Sweden	
Mercury	1.0
Tin	250
Cadmium	0.5
Lead	1.0
Histamine	200
DDT-DDD-DDE	5
Aldrin and Dieldrin	0.1
Hexachlorobenzene	0.2
Hexachlorocyclohexane	0.2
Trichloroform	0.1
PCB	2.0
United States	
Mercury	1.0
Aldrin and Dieldrin	0.3
DDT Total	5.0
Endrin	0.3
Heptachlor and Heptachlor Epoxide	0.3
Mirex	0.1
PCB Total	5.0
Chlordane	0.3
Toxaphene	5.0
Kepone	0.3

4.1.7 Physical and Chemical Profile of Sampling Sites

In the course of the survey certain field and laboratory measurements were undertaken to characterize the sampling locations and to identify factors which might be indicative of good crayfish habitat. The measurements included temperature, dissolved oxygen and specific conductivity taken with field measuring equipment at the time of sampling, and determinations of total dissolved solids and calcium in the laboratory from water samples collected in the field.

Table 9 provides the data from the field and laboratory mesurements. A correlation exists between size of crayfish and specific conductivity, total dissolved solids, and calcium levels. Largest numbers of crayfish over 7.5 cm were found in waters where specific conductivity exceeded 500 micro mhos/cm^2, where calcium exceeded 50 mg/L and where total dissolved solids exceeded 200 mg/L. Since these waters generally occur in southern glacial till, and are considerably more productive than northern waters it would be dangerous to assume a direct relationship between these parameters and size without first considering a host of other factors which may affect crayfish growth.

4.1.8 Significance of Crayfish as Food for Fish

A search of fisheries survey reports was undertaken to determine the importance of crayfish as food for fish species in the lakes surveyed (Table 10). No data are avail-

Table 9. Physical and Chemical Profile of Sampling Sites.

Location	Date	Water Temperature (^{o}C)	D.O. (mg/L)	Spec. Cond. ($\mu mhos/cm^2$)	Ca (mg/L)	TDS (mg/L)
Katepwa Lake	21.6.85	14.2	8.6	995	73	1060
Last Mountain Lake	5.7.85	17.8	9.2	2100	54	1620
Candle Lake	26.6.85	13.5	9.9	270	36	201
Saskatchewan River (at Cumberland House)	26.6.85	14.0	8.7	700	55	168
McBride Lake	27.6.85	18.2	10.0	365	49	290
Sturgeon-Weir River	8.7.85	17.0	8.5	100	12	83
Otter Lake	10.7.85	18.2	8.7	138	15	102
Nemeiben Lake	11.7.85	16.9	9.0	65	5.4	26
Pinehouse Lake	4.7.85	19.0	7.5	125	13	104
Churchill Lake	3.7.85	15.0	8.2	155	19	112

Table 10. Proportion (%) of Crayfish in Stomach Contents of Fish in the Surveyed Lakes.

	Walleye	Perch	N. Pike	Burbot	Reference
Katepwa Lake	8.4	18.5	15.3	--	Smith 1977
Last Mountain Lake	10.0	18.0	+	--	Smith 1974
Saskatchewan River		No Data			
Candle Lake	3.2	20.3	3.2	28.3	Johnson 1961
Cumberland Lake	40.0	--	48.0	100.0	Reed 1959
Limestone Lake	--	5.0	12.5	--	Lane 1967
Churchill Lake	--	--	--	3.7	Kallemeyn 1973
Pinehouse Lake	2.4	5.6	21.2	--	Chen 1972
Nemeiben Lake	--	+	11.0	49.0	Koshinsky 1963

able on food preferences of fish in the Saskatchewan River at Cumberland House. McBride Lake was test netted in March of 1984. Of the 33 walleye and 19 pike examined, none contained any crayfish.

Perch and northern pike consume crayfish most consistently. Pike are known to be the most opportunistic, feeding on what ever happens to be available. By contrast, walleye will consume crayfish where other dietary choices are limited or where crayfish numbers are high by proportion. Yellow perch and burbot show a preference for crayfish.

Following up on a concern that lake sturgeon rely heavily on crayfish in the Saskatchewan River at Cumberland House, a search of the literature identified no unique dietary preference for crayfish by this species (Sawchyn 1985). As is the case with walleye, pike, and burbot in Cumberland Lake, heavy consumption of crayfish by sturgeon in this area is entirely possible.

4.2 STAGE II - Bulk Sampling, Processing and Market Assessment

On the basis of crayfish size, numbers and ease of capture the field crew suggested that Katepwa and Last Mountain Lakes showed the greatest potential for commercial harvesting of crayfish. None of the northern waters provided any specimens that even approached the 10 cm size required for the export market. The largest crayfish caught in these

waters were taken from the Saskatchewan River near Cumberland House. Largest numbers per unit effort were obtained from McBride and Otter Lakes.

On the basis of these observations it was recommended that a bulk sample of crayfish be obtained from Katepwa Lake in the south. McBride Lake in the north would serve as the best sampling site with respect to numbers, however, none of the northern sites sampled would provide specimens of a size that would approach market standards.

4.2.1 Bulk Sampling

The first bulk shipment of live crayfish was delivered to Saskatoon from the Fort Qu'Appelle area on July 23. The specimens arrived in a large stock watering tank containing about 20 cm of ice water. Of the 1263 delivered, 270 were dead on arrival. Another 18 died before processing. A majority of the specimens were mature males. A conscious effort was made to return berried females to the lake. Approximately two thirds of the crayfish were dirty with accumulations of algal material particularly on the ventral abdominal surface.

The second lot of crayfish was obtained from the Qu'Appelle Lakes on August 6. About 30 man hours were involved in hand collecting 45 kg of crayfish over a period of three nights. Only 25 kg were delivered suggesting that the remainder escaped from the storage tank at the lake or were

removed by racoons, mink or humans. A total of 1529 live crayfish were processed. Approximately 1.5 kg (about 100) of crayfish died in the holding and transit period. The crayfish were delivered on ice with no water.

By August 15, delivery of more crayfish by the private supplier appeared in doubt. A collecting trip supervised by Saskatchewan Research Council staff was organized for August 19-21. Eight hundred and ninety-two live specimens were returned for processing. Only four dead crayfish were found on delivery, another 8-12 individuals died during storage in the field.

A final crayfish delivery trip from Katepwa Lake scheduled for the first week of September failed to materialize.

In spite of the fact northern crayfish were found to be small and low in population density in our preliminary survey, a determined effort was mounted by the Department of Tourism and Small Business to obtain a bulk sample from that region. The rocky shores of most northern lakes are not conducive to hand collecting or seining at night. Approximately 70 traps were constructed by Jean Poirier, a private entrepreneur working for Tourism and Small Business. These were set in a variety of lakes including Lac La Ronge, Potato Lake, Nipakamew River, Nemeiben Lake, Churchill River at Mountain and Drope Lakes, Bigstone, Egg, Weyakwen, Montreal and Besnard Lakes. The trapping effort approached 1000 trap nights. The highest production obtained was rated

at 1 crayfish/trap/night. Several hundred crayfish were caught but they were not sufficient and too small to mount a processing effort. Only 59 crayfish were delivered for processing from Lac La Ronge. A report on these fishing efforts (Wiens 1985) was prepared and is appended to this report (Appendix I).

An independent bulk sampling effort was undertaken at McBride Lake by the Saskatchewan Research Council in early September. Two nights of collecting by two employees yielded only 15 specimens.

The results of the bulk sampling experiences in southern Saskatchewan showed that crayfish can be hand collected from the shallow water with the aid of a light. The process is labour intensive but has the advantage of not requiring further sorting on shore. A limited trapping effort using Louisiana-style traps showed that crayfish were not being caught. Further work is required to select a suitable trap design and bait for these lakes.

By contrast northern lakes can not be sampled effectively by hand at night because of the rocky, often steeply inclined shore areas. The intensive trapping effort in northern Saskatchewan showed that trapping could not generate an economically viable operation even if the crayfish had been of appropriate size.

Temporary storage of live crayfish in tanks on the lake shore appears to be an efficient method of holding specimens

until processing. The crayfish were kept alive by pumping a continuous flow of water through the tanks. Care must however be exercised in ensuring that tanks are properly secured and covered to prevent the escape of crayfish.

Transporting crayfish over long distances in ice water resulted in high mortality by the time they reached their destination. Hauling live crayfish on ice separated by newspaper proved to be a more effective method. Crayfish could be kept alive for several days in this manner.

The large number of "dirty" crayfish, covered with algae and debris, caught in the first bulk sampling exercise on July 23 as compared to subsequent collections suggests that these specimens were still carrying exoskeletons from the previous fall and had not yet moulted. This period coincides with the disappearance of the last berried females. The second lot of crayfish obtained on August 5 and subsequent samples contained less than 10% dirty crayfish. This suggests that the ideal time for harvesting crayfish in southern Saskatchewan to avoid the dirty exoskeletons and berried females is the month of August. The problem of dirty exoskeletons did not occur in northern lakes.

The last bulk sampling trip in Katepwa Lake on August 19-21 found many of the crayfish in copulation.

An intensive bulk sampling effort at McBride Lake in the first week of September resulting in the collection of only 15 specimens where hundreds were observed and collected

during the earlier survey. This showed that cooling temperatures inhibited the nighttime feeding activity of crayfish. Similar effects were observed in the La Ronge area by Wiens (1985) who found a dramatic reduction in trapping success during this period. These results suggest that the month of August is perhaps the most appropriate month for crayfish harvesting in Saskatchewan.

4.2.2 Processing

Processing of the crayfish obtained from the Qu'Appelle Lakes followed the method described earlier. Twenty-six packages weighing an average of 505 g and containing an average of 36.5 crayfish per package were prepared from the first bulk sample. Fifteen trays were judged to be of inferior quality because of the dirty exoskeletons. Individual crayfish averaged 13.3 g.

The second shipment produced 48 trays, only four of which were dirty. The clean crayfish averaged 31.7 specimens per 500 g tray. The dirty ones averaged 27.0 specimens. The final collection from Katepwa Lake yielded 36 500 g trays with an average number of 24.8 crayfish per tray. Each crayfish averaged 19.9 g. The larger sized specimens were the result of a more thorough screening process during collection in the field. Only two trays of this last collection were dirty.

The vacuum packaged frozen trays of crayfish garnished

with fresh dill stems produced an attractive marketable product (Figure 3). Some problems were experienced in maintaining vacuum in the trays. There was a tendency for the plastic bags to puncture on the sharp projection of the claws of the crayfish. A layer of plastic film wrapped around the tray of crayfish before placing them in the outer vacuum bag appeared to solve this problem. An alternative would be to select a heavier gauge of plastic bag (not available at time of processing) to prevent this problem.

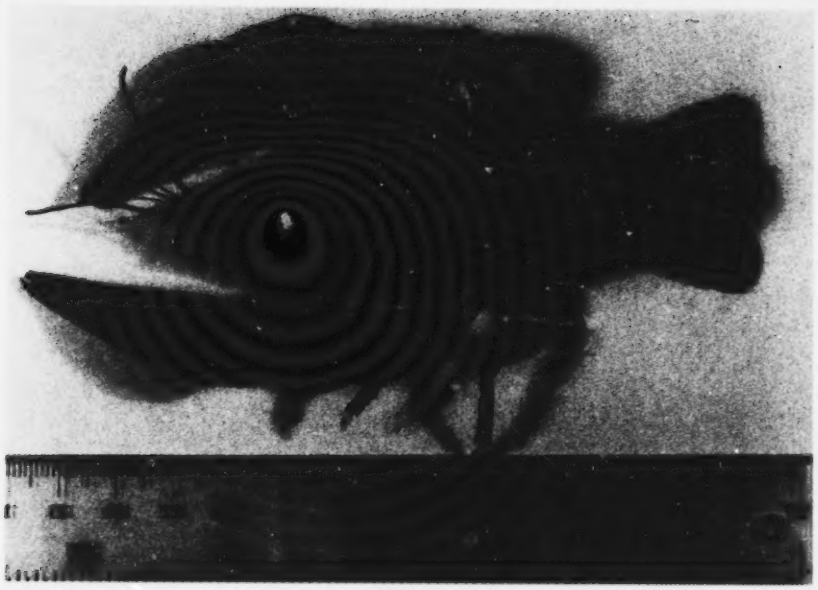
4.2.3 Market Assessment

4.2.3.1 Scandinavian Markets

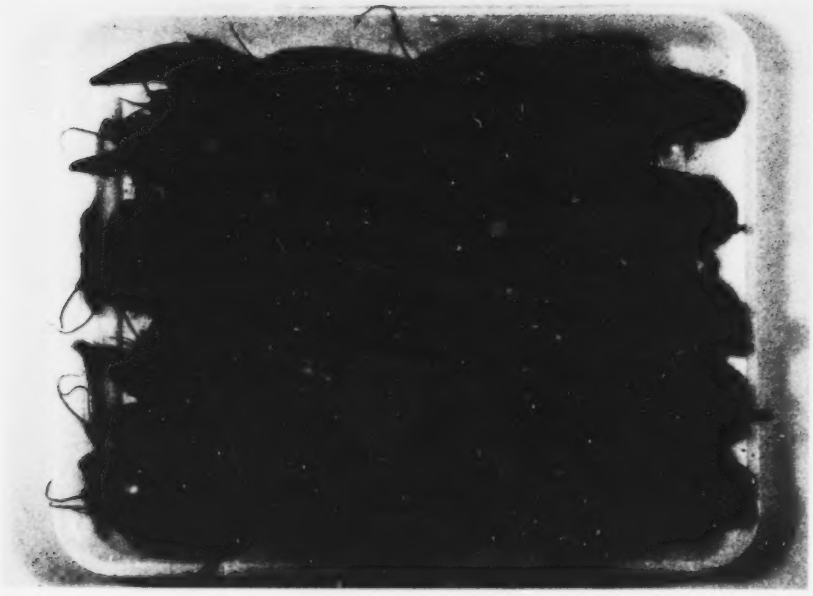
This study into the potential for developing a crayfish industry in Saskatchewan was sparked by inquiries about Canadian crayfish from Scandinavian countries where large quantities are consumed as part of an autumn festive tradition. Disease has decimated the local population to the extent that demand is considerably higher than domestic production.

Arbokem Incorporated, a Montreal based consulting company and participant in this study assumed responsibility for delivering a sample of Saskatchewan crayfish for a market assessment in Finland. A Finnish distributor was contacted and arrangements were made to deliver 10 kg or 20 trays for evaluation. A comparison would be made with local and imported Turkish crayfish.

The frozen crayfish were packed in dry ice and trans-



A.



B.

Figure 3. Processed Crayfish Showing: A. Large O. virilis Male; B. Tray of Crayfish Ready for Vacuum Packing.

ported to Edmonton where they were placed on a direct cargo flight to Finland. Although the method of shipment was extremely expensive it provided the best insurance that the product would arrive in good condition.

The results of the first shipment were encouraging. The packaging method and taste were acceptable:

> We have tasted your crayfish and came to following: Although they are not in brine they are not too dry. The taste is acceptable. Somebody will probably boil them in a liquor of their own to get them more juicy. This is done in Scandinavia with the Turkish and Russian crayfish though they are delivered in brine. (Telex from Olof Kjellman, Finland).

In the interest of protecting the recovering local crayfish population, Finnish law prohibits the importation or sale of crayfish smaller than 10 cm in length since these would be indistinguishable from local specimens. Saskatchewan crayfish fail to meet this minimum requirement.

A subsequent shipment to Sweden encountered a similar size restriction. The final evaluation on this sample has not yet been received but preliminary comments indicate that the size is below acceptable norm. Sweden restricts imports to specimens larger than 9 cm.

Arbokem Incorporated was contacted by another Swedish distributor who was investigating the feasibility of importing live crayfish from Canada. From our experiences this would be technically feasible, however, the size limitation plus the import restrictions on bringing in live crayfish

has terminated any further investigation of this approach.

Because of the size restrictions, our investigation did not proceed to the point of establishing a price that the Scandinavians would be prepared to pay for our product. Discussions with Dr. J. Huner, Southern University, Baton Rouge, Louisiana, showed that the main reason why Louisiana was not exporting crayfish to the Scandinavian countries was price. These countries were prepared to pay no more than $3.00 (Canadian) per kilogram to the producer which was considered below the cost of production. Our estimated return to the producer based on bulk sampling, would have to be from $6.60 to $8.80 per kilogram in order to generate a reasonable profit. Based on the size restrictions, the cost of production, the logistics and cost of transport, it is extremely doubtful that Canadian crayfish can penetrate the Scandinavian market.

4.2.3.2 Local Markets

Early recognition of potential difficulties with the export market allowed us to explore the local market for crayfish on a limited basis. Generally, it was determined that most people knew very little about crayfish and many were not aware that they even existed in Saskatchewan. The knowledgeable few included some ethnic Europeans and individuals who might have visited the southern United States. Introduction of crayfish on the Saskatchewan market would

require extensive promotion and consumer education.

The limited supply of crayfish on hand restricted introduction to three seafood outlets in Saskatoon:

1) Moby's Market - both wholesale and retail sales.

2) Charlie's Seafood Market - retail only.

3) Saskatoon Seafood Company Limited - retail only.

The wholesale price was set at $3.00 per 500 g tray based on the following reasoning:

1) The expected price for landed crayfish would be $2.50 - $3.00 per tray.

2) Estimated cost of processing and packaging would be $1.00 per tray.

3) A suggested retail price would be $5.50 per tray.

4) The price would include a discount offered over an expected wholesale price of $3.50 - $4.00 to hopefully get better feedback of customer comments.

A week before Christmas, the outlets were contacted with a free sample tray to be tried by the owner. The expected response was that each would try one or two trays on consignment. This was not the case. Each store purchased 10-12 trays with little or no selling required. Granted, the holiday season was an excellent time to introduce a different new product (Saskatchewan lobster).

In the second week of January the outlets were contacted to assess consumer response. With the exception of one or two trays the product was sold out. One outlet marked up

its price to over $6.00 and was not moving its product as quickly. This store was planning to offer samples to its customers and to explore the institutional markets. The price of $5.50 did not appear high and was probably in line with lobster at $20.00 - $22.00 per kilogram. A maximum acceptable price appeared to be $6.00/tray ($12.00/kg).

The most common customer comment was that the crayfish were too small and the quantity of meat was not worth the effort. A few customers complained that the dill flavour was too strong. Lack of knowledge of the product means that promotion and instructions (recipes) on the preparation, serving and peeling would be beneficial.

At the time of preparation of this report the potential for developing a restaurant market was being investigated. The chef of a particular restaurant was planning to offer a jambalaya-type dish to go with the theme of the restaurant. Included in the dish would be catfish, clams and crayfish. The chef will be contacted for an assessment of the experimental promotion.

5 SUMMARY AND CONCLUSIONS

5.1 STAGE I - Preliminary Population Survey and Sampling Site Selection

1. Results of the population survey show that crayfish found in Saskatchewan are members of one species, Orconectes virilis.

2. Crayfish found in the Prairie and Parkland regions reach or exceed minimum requirements of 7.5 cm considered acceptable for domestic consumption but fewer than 2% reach the 9-10 cm size required for export to Scandinavian markets. Few crayfish from northern Precambrian lakes reach minimum acceptable standards for human consumption.

3. Lowest populations of crayfish occur in the western and northwestern areas of the province. Highest numbers were collected in the Qu'Appelle Valley and Last Mountain Lake.

4. Higher populations and larger size appear to be correlated with high specific conductivity, calcium and total dissolved solids of the water but further studies are required to determine whether these may be a function of other parameters such as temperature and trophic status of the lakes.

5. Levels of selected potentially toxic elements and organic compounds in edible portions of crayfish from the Qu'Appelle Lakes are within limits considered acceptable for human consumption.

6. Crayfish populations within a lake can not be as-

sessed on the basis of a small number of samples because of the high variability between even apparently similar habitats.

7. There is generally a straight line relationship between the total length of crayfish and the tail length. The slope of the line is affected by the sex and lake. Females have a larger proportion of tail to total length than males. Generally lakes with smaller crayfish, i.e. northern lakes, have better tail growth relative to total length.

8. Crayfish are a preferred food item for yellow perch and burbot. They are frequently taken by northern pike which are opportunistic feeders, and are occasionally eaten by walleye where crayfish numbers are high or alternative feed is scarce. No data are available on crayfish as food for sturgeon.

5.2 STAGE II - Bulk Sampling, Product Preparation and Market Assessment

1. Crayfish harvesting should be encouraged for the period from August 1 to reduce the capture of berried females and to enhance physical appearance. This is the period in which most crayfish will have moulted and dirty exoskeletons discarded.

2. Bulk sampling of crayfish using baited chicken wire traps patterned after the Louisiana traps was unsuccessful.

3. Harvesting of crayfish by hand collecting at night has potential in southern lakes where populations are high

and the littoral zones sandy and accessible.

4. An ideal harvesting method which is efficient, not labour intensive, and which will work in both northern and southern habitats needs to be developed.

5. Holding crayfish in covered lake shore tanks is an efficient way of keeping crayfish alive and allow gut contents to be purged before processing.

6. Crayfish can be transported efficiently and stored live for several days by being kept on ice separated by an insulating layer of newspaper or other material.

7. Crayfish should not be transported in water without aeration.

8. Crayfish processing following the prescribed recipe offers an attractive, appetizing product for the seafood market.

9. Packaging processed crayfish in vacuum packed trays provides an acceptable product for the export and domestic market and eliminates the need to handle frozen liquids. Vacuum packing permits long term storage when frozen and simplifies serving by simply microwave heating of the packages.

10. Vacuum packing of crayfish requires extra precautions to prevent the plastic film from being ruptured by sharp projections of the crayfish exoskeletons.

11. The export market in Scandinavian countries is not available to Saskatchewan crayfish because of their failure

to meet import restrictions on size.

12. It appears that, unless better, more efficient, methods of harvesting are developed, Saskatchewan crayfish could not be made available for export at competitive prices even if size were not a limiting factor. A price of $5.50 to $6.50/kg for a processed product to the producer is projected.

13. A limited domestic retail and institutional market is available through local seafood outlets. At the moment it is difficult to see a potential market beyond 500 kg per year in Saskatchewan.

14. Considerable promotion would be required to expand the market for this relatively unknown product.

15. The method of processing and packaging is acceptable with the vacuum packaging being extremely important in the retail trade. This is based primarily on the appearance.

16. Institutional promotion is essential with special emphasis on holidays, and ethnic festivals.

17. The present crayfish demand can be satisfied by crude hand picking methods. Research is required to develop more efficient harvesting methods more appropriate to local situations.

6 REFERENCES

Chen, M.Y. 1973. Limnology and Fisheries of Pinehouse Lake, 1972. Fisheries Tech. Rept. 73-2. Sask. Dept. Natural Resources.

Crocker, D.W. and D.W. Barr. 1971. Handbook of the crayfishes of Ontario. Univ. Toronto Press. 158 p.

Johnson, R.P. 1963. Biological Survey of Candle Lake, 1961. Fisheries Tech. Rept. 63-1. Sask. Dept. Natural Resources.

Kallemeyn, L.W. 1973. The Peter Pond and Churchill Lakes Fishery, 1969-1972. Fisheries Tech. Rept. 73-3. Sask. Dept. Natural Resources.

Koshinsky, G.D. 1964. Biological Survey of Nemeiben Lake in North Central Saskatchewan, 1960-63. Fisheries Tech. Rept. 64-1. Sask. Dept. Natural Resources.

Lane, C.B. 1967. The Limnology, Fisheries, and Management Potential of 17 Lakes Located Along the Hanson Lake Road, 1964-66. Fisheries Tech. Rept. 67-3. Sask. Dept. Natural Resources.

Reed, E.B. 1959. The Limnology and Fisheries of Cumberland and Namew Lakes, Saskatchewan. Fisheries Tech. Rept. 59-2. Sask. Dept. Natural Resources.

Sawchyn, W.W. 1985. A Review of Crayfish Literature Relevant to the Development of a Crayfish Industry in Saskatchewan. Sask. Res. Council Tech. Rept. 174.

Smith, N.W. 1976. Last Mountain Lake Limnology and Fishery, 1974. Fisheries Tech. Rept. 76-8. Sask. Dept. Tourism and Renewable Resources.

Smith, N.W. 1977. Qu'Appelle Fisheries. Part I - Populations and Spawning Habitats. Fisheries Tech. Rept. 77-1. Sask. Dept. Tourism and Renewable Resources.

Wiens, B. 1985. Trial Harvesting of Northern Saskatchewan Crayfish to Assess the Physical and Economic Feasibility of such an Industry. Tech. Rept. for Jean Poirier, La Ronge, Sask.

APPENDIX I

TRIAL HARVESTING OF NORTHERN SASKATCHEWAN CRAYFISH TO ASSESS THE PHYSICAL AND ECONOMIC FEASIBILITY OF SUCH AN INDUSTRY

by: Brian Wiens

prepared for:

Jean Poirier
LA RONGE, Saskatchewan

November, 1985

ACKNOWLEDGEMENTS

We wish to thank Joe Hnatuik and Joe Cools from Tourism and Small Business for initiating this project, and for providing advice and assistance along the way. We would also like to thank Rob Wallace from Fisheries Branch, Department of Parks and Renewable Resources for his willing cooperation and counsel throughout the duration of this project.

TABLE OF CONTENTS

	Page
Introduction	1
Status of Crayfish Harvesting in Northern Saskatchewan	2
Description and Discussion of Capture Methods	2
Analysis of Trap Performance	5
The Economics of Crayfish Trapping in the La Ronge Area	7
Discussion of Future Potential for Northern Crayfish	12
Conclusions	15
References	16

AREA REPORTS

		Page
1.	Montreal River - La Ronge Lake Area	18
2.	Bigstone - Egg Lake Area	21
3.	Mountain - Drope Lake Area	23
4.	Nemeiben River - La Ronge Lake Area	26
5.	Potato River - La Ronge Lake Area	29
6.	Weyakwin - Montreal Lake Area	32
7.	Besnard Lake Area	34

ILLUSTRATIONS

		Page
Figure 1.1	Cylindrical Type Trap	4
Figure 1.2	Box Type Trap	4
Figure 1.3	Map of La Ronge Region	17
Figure 1.4	Map of Bigstone Lake - Montreal River - La Ronge Lake	20
Figure 1.5	Mountain Lake - Drope Lake	25
Figure 1.6	Nemeiben River - La Ronge Lake	28
Figure 1.7	Potato Lake - Potato River - La Ronge Lake	31

INTRODUCTION

Due to the massive European demand for freshwater crayfish (especially the Scandanavian countries), interest has grown worldwide over the commercial possibilities of harvesting and cultivating crayfish for human consumption. Besides the very limited use of crayfish as bait for sportfishing, Canadian involvement in this industry has been virtually non-existent. Several experimental harvesting and marketing projects have been recently undertaken in Ontario (1984), British Columbia (1985), and Saskatchewan (1985).

The Ontario study (which dealt with a crayfish species similar in size to that found in Saskatchewan), attempted to penetrate local domestic markets whose demand was being met by overseas producers. They also exported a small quantity of Canadian crayfish to be evaluated on the Belgium market. In both cases the limiting factors appeared to be the quality of the crayfish (specifically - the size and texture of edible meat), and the high cost of production.

The investigation that is presently being completed in British Columbia is testing the crayfish productivity of several lakes on Vancouver Island. Although the Crayfish are naturally much larger (a different species with average size around 75 g), and the productivity is good, the cost of production again seems to out-weigh the present consumer demand.

The Saskatchewan effort, of which this is a part, focused on both southern and northern water systems with the intention of establishing a production feasibility and product evaluation for each area. It was originally targetted that approximately 6,000 representative specimens would be harvested in each region, and after proper processing would be shipped to the Scandanavian market for consumer evaluation. The actual marketing of the crayfish was to be done by Arboken Inc., a company operating out of Montreal.

This then is a report on the potential of a crayfish harvesting industry in northern Saskatchewan (specifically the La Ronge area), based on the information gathered during the trial harvesting period of July - September, 1985. It does not deal with crayfish biology, but rather it should disclose the physical and economic requirements of crayfish captive in northern Saskatchewan.

STATUS OF CRAYFISH HARVESTING IN NORTHERN SASKATCHEWAN

Although the majority of residents in northern Saskatchewan are aware of the presence of crayfish in the surrounding lakes and rivers, few have thought of harvesting them commercially. To a select group, crayfish represent an occasional snack, while to the commercial fishermen in the area, they are a nuisance. Up until this project began, crayfish in this region had never been subject to any type of concentrated fishing pressure. As such the task of harvesting 6,000 crayfish in an efficient manner represented a challenging problem.

DESCRIPTION AND DISCUSSION OF CAPTURE METHODS

There exist more than a few possible methods by which crayfish can be captured. However, each methods' efficiency and therefore its' commercial application is limited by factors such as shoreline type, crayfish population density, water depth, bottom profile, etc. The following will briefly describe and evaluate the commercial potential of several capture methods which were tried and tested in northern waters.

Trapping

Due to the thriving crayfish industry in the United States there is now a good supply of informative material available on the performance of various types of crayfish traps. Many of these traps were designed specifically for use in farm ponds and other controlled situations where size and shape are not as important as the catching ability of the trap. It was quickly discovered that on the much more remote and rugged water systems of the La Ronge area, factors such as ease of handling and size were also a priority.

Two traps (similar in structure) that are rated highly for open water fishing are the standard minnow trap and the Finnish made Evo-trap. Another trap recommended specifically for precambrian conditions was a box-type trap tested in Ontario (1984) by Ogilvie.

As such two traps were designed and constructed (almost exclusively of local materials) to test their ease of handling and performance. The best design would then be used to produce another sixty traps by which the local crayfish population could be analyzed for its commercial potential.

1. Cylindrical Trap (See Figure 1.1)

   The trap had a total length of 33 cm, a diameter tapering from 25 cm (bait end) to 21 cm (funnel end). It had a galvanized steel wire frame. One lead fishing weight (6.0 oz.) was clamped on one of the six struts directly below an attached snap (on the end of another strut) which fixed the

traps to the running line. The relative positioning of the connecting snaps and weight is important if the trap is to assume a horizontal position on its side after being set. A light mesh sock of flexible plastic was stretched over this frame; one end attaching to a ring 5 cm in diameter (to form the funnel), the other end was left open to provide access to the bait area. A small clip was fashioned to open and close the mesh on the bait end of the trap.

The cost of this trap was approximately $10.00/trap including snap, running line and buoy.

2. Box-Type Trap (See Figure 1.2)

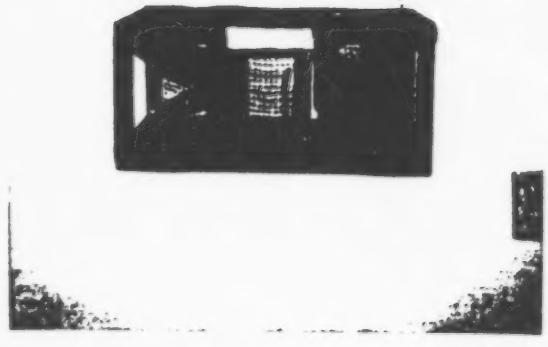
This trap was rectangular in shape - 43 cm long and 20 cm wide. The frame was constructed exclusively from 3/4" x 3/4" coated softwood, and covered with small-mesh aluminum screening. A 25 cm x 15 cm rectangular opening (which terminated a ramp), was located at each end of the trap. This opening had a cotter-pin assembly hanging over it (12 pins/side) to inhibit crayfish escape. A rawhide hinged door (13 cm x 17 cm) was located on one side of the trap to allow access to the bait as well as to release captured crayfish. Mining core was attached to the bottom of the trap for ballast, while a clip was located on top of the trap to connect it to the running line. The trap was completely black in colour. One box-type trap was also made to be tested without the cotter-pin assembly.

The cost of this trap was approximately $12.00/trap.

The higher cost is a result of the price paid for the mesh (40¢/sq. ft.), and the cotter-pin assembly ($1.20 extra).

Figure 1.1 Cylindrical Type Trap

Figure 1.2 Box Type Trap



ANALYSIS OF TRAP PERFORMANCE

Both traps proved to be functional, but each also had flaws that would be costly in any commercial operation. The cylindrical trap had the following disadvantages:

1. The catchability was lower than the box traps', however if the traps were checked on a 24 hour basis it was only marginally lower because no crayfish escaped. On two different occasions 10 crayfish were placed in each trap for a 48 hour period. The cylindrical trap always retained 100% of its' crayfish while the box trap lost up to 40% (that is the box trap without the cotter-pin assembly). The box trap with the cotter-pin assembly also retained 100% of its' crayfish as long as it was set on level ground.

2. The task of opening the trap to rebait it and remove captured crayfish was slow and inefficient. The simple clamp system worked well enough for what we had to accomplish, but a commercial operation would be recommended to design some type of clasp system.

3. The plastic mesh that covered the trap was not durable enough to last more than one season. This was only considered to be a temporary problem as Nalle Plastics, Inc. (a Texas based company) produces all sizes of black Duronet mesh that would last at least two seasons. The trap frame itself is fairly permanent.

The box-type trap also had several disadvantages:

1. The cotter-pin assembly proved to be more trouble than it was worth. The cotter-pins frequently caught each other or flipped up and jammed when the trap was being set. A trap is rarely set on a level surface. As mentioned, the catchability of the trap was good, but without the cotter-pin retaining system the retentive ability dropped.

   *The simpler the design without losing overall performance the better.

2. Because of the rocky bottom profile in many of the surrounding lakes, the box-type trap frequently settled on its side while being set. This makes trap-entry all the more difficult. The cylindrical trap settled well on both rocky and inclined surfaces.

3. The total length of this trap was greater than the cylindrical trap due to the added entrance ramp. However it was not long enough as once the ballast and bait were added the interior of the trap became crowded. This allows for easier escape by the captured crayfish. Although this may seem to be an easily correctable problem it is not. Once in the water, compactness becomes important as traps have to be pulled, transported, rebaited, and reset in a boat that is

of limited size.

4. The main structural members of the trap should be constructed of a treated hardwood. This increases cost. The alternative would be an all-wire trap, similar to the ones used for crayfish farming, which would be impractical under these conditions.

It should be noted with reference to point 3 (under box trap analysis), and in regard to the choice of cylindrical trap type that there are two possible trapping strategies. The first is to use small traps and cover a large area but fish it longer. This agreed with the purposes of this study, which was to assess the harvestable crayfish population in many different areas. The second strategy is to use larger traps (which are more expensive, therefore implying a smaller quantity), cover a smaller area but fish it for a shorter time period. This is, of course, assuming that the larger traps catch proportionately more crayfish, thereby depleting the standing crayfish stock faster.

In side-by-side sets, the cylindrical trap performed very well against both the Evo-trap and the standard minnow trap. The color of the traps did not seem to affect catchability.

Trap Setting Procedure

Traps were set in lines of five, each trap attached to the same rope approximately 2.5 - 3.0 m apart. This proved to be a highly satisfactory arrangement, as only one buoy and one anchor were required for each set of five traps. Trap setting and checking is also accelerated, as 4 sets (20 traps) can be pulled, rebaited, transported, and reset at once. After some experience was gained using the above method, it became possible for 2 people to pull, empty, rebait and reset sixty traps in approximately ninety minutes.

When fishing in isolated areas (such as Mountain or Drope Lake), 60 traps can easily be transported and set from the boat in one trip. Due to the reduced work area, setting time increases.

Bait Types

Only natural baits were used. These included trout, pike, pickerel, white fish, beef liver and beef heart. Little or no difference was determined to exist among the fish baits, whether heads or frames were used. Bait that was already decomposing (out of the water) attracted crayfish just as well as fresh bait. Baits that were checked every 12 hours remained productive for two sets, or 24 hours. After 24 hours crayfish are no longer attracted to the bait (it becomes leached out), and captured crayfish attempt to escape. Beef liver and beef heart consistently produced significantly less crayfish than fish baits.

It is important to realize that testing of any kind (bait or

trap) in the natural environment was limited by the fact that very few crayfish were caught. As well, in some areas the crayfish seemed to be concentrated in 'niches' while 30 ft. down the shoreline no crayfish were captured. As is indicated in the area reports, the more productive spots or niches were not always predictable. This makes any type of numerical analysis difficult and inaccurate.

THE ECONOMICS OF CRAYFISH TRAPPING IN THE LA RONGE AREA

An economic model was created for a single operator fishing in the La Ronge area. In addition to the basic assumptions that are clearly stated in the model, there are several other very important factors which need to be defined. They are as follows:

1. At the present time there is no existing market for Saskatchewan crayfish. As indicated, 6,000 northern crayfish were to be tested on the Scandanavian consumer market. To supply this number of acceptable size crayfish from northern waters became all but a physical impossibility. However, a limited quantity of southern Saskatchewan crayfish were shipped to Scandinavia for evaluation. As it turned out, the quality was good in terms of taste and texture, but the size was too small. By law, Sweden and Finland cannot import crayfish whose size is less than 10.0 cm. A German representative inspected the largest crayfish that this study produced and stated that the size was barely acceptable. The cut-off appears to be 10.0 cm, whereas the largest crayfish that this area can produce has an average size of 8.0 cm.

   Even with the foreign market eliminated, this still leaves the possibility of developing local domestic markets. As such, the market that the fisherman in the model caters to is a fictitious one which will accept all crayfish over 7.0 cm.

2. The price paid to the fisherman (on a per kg basis) is an estimated figure. The size factor substantially diminishes the value of the crayfish. Unless a high demand market is created, any potential fisherman could expect to receive no more at this time. A good indicator that $5.25/kg is a liberal price is the fact that British Columbia crayfishermen are now receiving $3.30 - 4.40/kg for a much larger crayfish species.

3. It is debatable that the naturally occurring crayfish productivity that this study claims to exist might be erroneous due to unforseen factors. These factors could possibly be the effects of mating, molting and fall migrations on the catchability of northern crayfish. However, the area reports make clear that a high productivity for the areas tested did not reach 2 crayfish/trap even when all the traps were concentrated in a

so-called 'productive' spot. Therefore, according to this figure, a commercial fisherman running 200 traps would be lucky to achieve a productivity of 1 simply because many traps would fall in unproductive water. This illustrates - along with the findings of the economic model - that if the productivity in these areas was tripled or even quadrupled, that would still not necessarily make them commercially viable waters.

4. As indicated in the model, the crayfishing season is stated to be only 12 weeks in duration. This is a direct result of the fact that in all certainty, the standing crayfish population in the given areas could not support one operator (200 traps) for even that length of time. In a truly productive area such as Wisconsin (Threinen - 1965), the productivity was restricted to a mean of 11.3 simply because additional crayfish are hesitant to enter the traps due to such conditions as crowding, etc. In the La Ronge area the productivity is extremely low simply because a large crayfish population (indicating a high population density) doesn't exist.

   All the indicators from the data collected imply that the crayfish resource is extremely limited.

Micro-Economic Model for Crayfish Harvesting Operation in La Ronge

Assumptions:

1. Owner/operator and hired hand 8 hours/day
2. 200 traps set 5 days/week for 12 week season
3. Fisherman responsible to capture, clean and deliver crayfish locally. Holding for 1 week maximum.
4. Undefined market will accept all crayfish at or over 7.0cm. (Predicted average size of 7.5 cm)
5. Productivity in this case refers to crayfish kept, not crayfish captured. All crayfish under 7.0 cm are sorted and released, or traps are previously designed to allow all undersized crayfish to escape.
6. The cost of obtainng bait is included within the labour cost.

Equipment Costs:

17' boat, 20-25 hp motor/trailer	new	$4,000
	used	2,500
200 traps @$10/trap (including buoys, anchors, and line)		2,000
3 holding pens @ $50/pen		150
TOTAL INVESTMENT		$4650 - 6,150

Operational Costs:

Labour: Owner/operator - 480 hrs @ $4.50/hr	$2,160
Hired hand - 480 hrs @ $4.50/hr	2,160
Transportation -	
Boat - 3 hrs running time/day ($12.50)	750
Car or Truck - 35 km/day @$0.14/km	294
TOTAL OPERATIONAL COSTS	$5,364

Gross Income:

High Productivity Lake (4 crayfish/trap/day)
800 crayfish @ $5.25/kg = $117.60/day
Gross income/season $7,056

Predicted Productivity Lake (2 crayfish/trap/day)
400 crayfish @ $5.25/kg = $58.80/day
Gross income/season $3,528

Net Income:

High Productivity Lake: Even with operator working for minimum wage, only $1,692 remains after costs. Loan re-imbursement very difficult even if a no-interest loan is available.

Predicted Productivity Lake: Income does not cover cost $1,836 deficit without capital investment even considered.

The model clearly indicates that at a productivity of 4 (which is double the predicted productivity) a given operator in the La Ronge area would have difficulty repaying his initial investment. At the predicted productivity, the same operator would not even cover his seasonal costs.

It must be noted that the initial costs, and the operational costs that are outlined in the model are fairly clear cut and represent accurately the situation for any potential crayfisherman in northern Saskatchewan. However, the productivity that was found to exist for this region does not limit the potential for other northern regions (although it is a good indicator). It was mentioned that small isolated populations of larger and more abundant crayfish do exist in this area. Therefore it is possible that the conditions which allowed this population to exist might be found in other northern areas, on a much larger scale, thereby providing a commercially harvestable population.

In summary, it can be stated that the factors which presently limit the development of a crayfish trapping industry in the La Ronge area are:

1. The small crayfish size which seems to be characteristic of the standing population (which limits market opportunities).

2. The size of the gap that exists between the naturally occurring productivity and the productivity that is required to substantiate a commercial crayfish trapping operation.

Electrofishing

Due to factors such as cold water, short summers, inactive winters, etc. the naturally occurring crayfish production in northern Saskatchewan lakes and river systems was predicted to be low, relatively speaking. However, due to the sheer area of water bodies found in this region, a very large volume of crayfish could possibly still be produced. Since the efficiency of a crayfish trapping operation drops dramatically with low productivity (crayfish caught/trap/night), it would seem only logical to pursue other avenues or methods of crayfish capture. Electrofishing represents such a possible method.

The electrofisher that was used for this operation was a backpack model, TYPE-V Electro-Fisher, manufactured by Smith-Root. The unit operated on a 12 volt Ski-Doo battery and produced an AC current with a voltage of either 325 or 425 volts. Pulse-width and frequency were also variable. This particular piece of equipment was designed for fish collection rather than crayfish collection, however it functioned well enough to give an indication of its ease of operation and effectiveness . Crayfish respond better to a non-pulsating , DC shocker.

To test the capabilities of the machine, crayfish were captured live using other methods and released in an ideal environment for electrofishing (shallow water, smooth bottom). Unlike the reaction of other fish species that of the crayfish is not so spectacular. On the first pass over any given area, crayfish are stimulated to crawl out of their hiding places and will sometimes flip over once or twice before becoming relatively inactive. It is rare when the reaction causes the crayfish to become free swimming (actually left of the substrate) as the usual reaction is one of crawling.

The best results were achieved on the higher voltage setting (425 v) and a frequency setting ranging from 60-80 c/s. Varying the pulse width appeared to have no influence on the reaction of the crayfish to the given stimulus. The optimum horizontal distance between electrodes was 1.5-2.0 m.

In analyzing the effectiveness of electrofishing as a commercial crayfish harvesting tool, we were restricted by the limited capabilities of the one machine at our disposal. According to an

update by Huner (1984) on crayfish harvesting methods in the United States, electrofishing devices have been developed which will stimulate crayfish to flip upwards thereby allowing them to be captured mechanically. This device releases a pulsating DC current, also of high voltage, but of low amplitude. It is noted in the report, that at this time this system is effective only in well-managed ponds with uniform depths and soft-stemmed vegetation.

The development of this crayfishing system has some potential for harvesting crayfish in the La Ronge area. As indicated in the area reports, some of the shoreline in many of the surrounding lakes has a fairly uniform gradient (less than 30 degrees below the horizontal), with bottom structures composed mainly of small and intermediate size rocks. Vegetation is usually very limited. This type of area does not represent commercially trappable habitat (as will be shown) but it does contain a standing population of crayfish. As such, if an individual developed this system to work under these conditions, it would seem reasonable that the crayfish from many kms of this type of shoreline could be harvested.

Several limitations came to mind immediately when considering the applications of such a proposal in northern Saskatchewan:

1. Even if it was possible to develop a system that worked effectively on the type of shoreline described above, any operator would be forced to move from place to place searching for shoreline that would accommodate the limitations of his machine. This would incur high transportation costs and lots of 'downtime' for both operator and machine.

2. Because of the depth limitations of such a machine (estimated maximum operating depth of 1.0-1.5 m), the average size of crayfish caught would be no more than 6.0-7.0 cm in most areas. Similar to nightfishing, this represents a seemingly insurmountable problem.

3. As water temperatures drop in autumn, crayfish tend to move into deeper water. This migration means electrofishing equipment becomes practically useless.

4. It is almost certain that the naturally occurring crayfish population would not be able to support such a fishery even if a market was found for smaller crayfish.

It becomes obvious that although electrofishing looks promising in theory, in practice its commercial applications are extremely limited. In order to be considered a commercial option, a mechanical harvesting system with a much greater depth capability (6-12 ft) would have to be developed.

Nightfishing

The nocturnal behavior of crayfish (which usually crawl or swim into shallow water at night) offers a potential harvesting method. Wherever there are crayfish-inhabited shoreline areas that are shallow (1-3 ft.), smooth-bottomed and not too heavily vegetated, an individual armed with a flashlight, scoopnet, hipwaders and a pail can rapidly capture a high percentage of the crayfish he spots. This sounds just great, and clear northern water provides good light penetration, but there are several restricting problems:

1. Crayfish have extremely good mobility and over 30% of crayfish sighted escape. The deeper the water, the higher the escape rate.

2. As indicated, relatively smooth, gently sloping shorelines are required. The La Ronge area has many lakes which meet the second condition, but the bottom is usually composed of boulders or jagged rock which make wading impossible.

3. The average size of crayfish captured using this method is smaller than that of trapping. Larger crayfish are often seen in deeper water (4-6 ft.) where capture is difficult. When dealing with a species whose maximum size is barely acceptble, this can cause definite problems.

4. Even if all the crayfish caught were of marketable size, this method would still not be a viable option simply because the most productive crayfish areas cannot be fished using this method.

Netting

On two occasions a 10-meter, 1½" mesh net was set in both flowing and still water, in an area where crayfish had previously been captured. Each time the net was left for 24 hours, but no crayfish were captured.

There was initially some interest in the possible applications of seine-netting for crayfish capture. This proved to be shortlived as efficient seine-net operation is restricted to open water or beach areas with a sandy or smooth bottom.

DISCUSSION OF FUTURE POTENTIAL FOR NORTHERN CRAYFISH

The naturally occurring size and population density of northern Saskatchewan crayfish necessarily exclude them from becoming competitive in an international market. As well, Canadian markets are practically non-existent and any demand is presently being met by foreign suppliers. The size and availability of local crayfish again limits any potential to penetrate existing markets or develop new ones.

There are a number of other possible approaches to the

utilization of this resource. The following ideas are areas of interest that at some time could represent commercial opportunities:

1. Little or no research has been done in the western Provinces on the effectiveness of using crayfish as angling bait. At the present time crayfish are not on the approved species list and by law cannot be used as bait in Saskatchewan (Sawchyn - 1985). Across the border, crayfish are used fairly extensively (both live and dead) by American fishermen angling for both bass and pike. One local merchant who deals in sporting goods commented that American tourists frequently ask for crayfish which they intend to use for bait.

   If an individual or corporate interest could develop an efficient harvesting system for small crayfish (1.5-4.0 cm) and generate public interest in using them as bait, it might be possible to legalize this practice in Saskatchewan. It should be made clear that the crayfish would not be sold live, but rather would be preserved either in some appropriate liquid, or dehydrated.

   There are now no regulations in place which govern size limits of crayfish, sex or season of harvesting (Sawchyn - 1985). It can be expected that if an industry such as this were to develop, guidelines would be set in place which would protect the resource from over-exploitation. Unlike the capture of mature crayfish, mass harvesting of young-of-the-year crayfish represents a possible threat to the whole crayfish population.

2. Culture of the crayfish species Orconectes Virilis for human consumption occurs on a very small scale in North America. The principal reason for this lies in the cannibalistic and aggressive behavior of the species, particularly during and following molting when shells are soft (Boubjerg - 1970). However, the species is cultured commercially in the United States specifically for use as fish bait. In such an operation the crayfish are harvested while still very young and as such do not repesent a threat to each other.

   The procedure which might apply to Saskatchewan conditions is outlined as follows by Crocker and Barr (1971):

   Species Recommended: Orconectes Immunis (similar to virilis).

   Pond area recommended: Under ½ acre (easiest to manage)

   Stocking Instructions:

   Fall: 600 - 1,000 mature (2½") crayfish per acre
   Spring: 300-500 females with eggs per acre

Fertilization of Pond:

Commercial fertilizer (6-12-6) or (10-10-5) broadcast from shore over pond surface. 200 lbs/acre at 3 week intervals during spring and summer.

Feeding:

Supplementing natural food with soybean meal, fish meal, cracked corn, and potatoes. Hay, fresh or dried, may have considerable value; about 5 tons/acre portioned out through the summer.

The obvious limitations to such a program would be:

a. The legality and effectiveness of using crayfish as bait in Saskatchewan.

b. The availability of mature male and female crayfish to be used as stocking material.

c. The existence of suitable ponds.

3. The economic model which was created for a fisherman in the La Ronge area was based on the assumption of full-time employment for the duration of the season. If the same problem is approached from the standpoint of part-time employment (4 hrs/day) for an individual who already has a boat, and who is catering to a local market, the situation changes somewhat. However, it still does not become an economically viable operation until the following very demanding conditions are met:

   a. Owner/operater using 60 traps manages to attain a productivity (all crayfish larger than 7.0 cm) of 3.0 (180 crayfish/day).

   b. Local retailer willing to package and sell crayfish for $6.00/lb ($13.25/kg), a 30% mark-up on the price the fisherman receives - $4.60/lb ($10.14/kg).

It is worth noting in regard to condition 2 that though crayfish may be thought of an an exotic food, at $6.00/lb consumers are paying in the neighborhood of $25-30/lb for edible meat.

CONCLUSIONS

1. Trapping proved to be the most operative method of crayfish capture for this region.

2. The naturally occurring crayfish productivity in the La Ronge area was found to be extremely low.

3. Although crayfish size varies substantially from area to area, the overall average size of crayfish captured was 7.0-7.5 cm.

4. Low productivity results in a high cost of production regardless of the size of the operation.

5. The size and availability of northern Saskatchewan crayfish makes them unacceptable on an international market.

6. On a provincial or local level the size factor limits any potential to penetrate existing markets or develop new ones.

7. There is potential for the development of a crayfish bait industry in Saskatchewan, however much more work is required if such a proposal is ever to become a commercial option.

REFERENCES

1. Huner, J.V., 1985, An Update on Crayfish Aquaculture, Aquaculture Magazine, July 1985.

2. Meglitsch, P.A., 1967, Inveteilrate Zoology.

3. Ogilvie, D.M., 1984a. Trial Harvesting and Marketing of Ontario Crayfish. Tech. Rept. prepared for Clearwater Bait Inc., Wraitan, Ont.

4. Pfister, V.A. and R.P. Romaire. 1983 Catch Efficiency and Retentive Ability of Commercial Crayfish Traps. Aquacult. Eng. 2:101-118.

5. Sawchyn, W.W., 19[illegible] A review of crayfish literature relevant to the development of a crayfish industry in Saskatchewan.

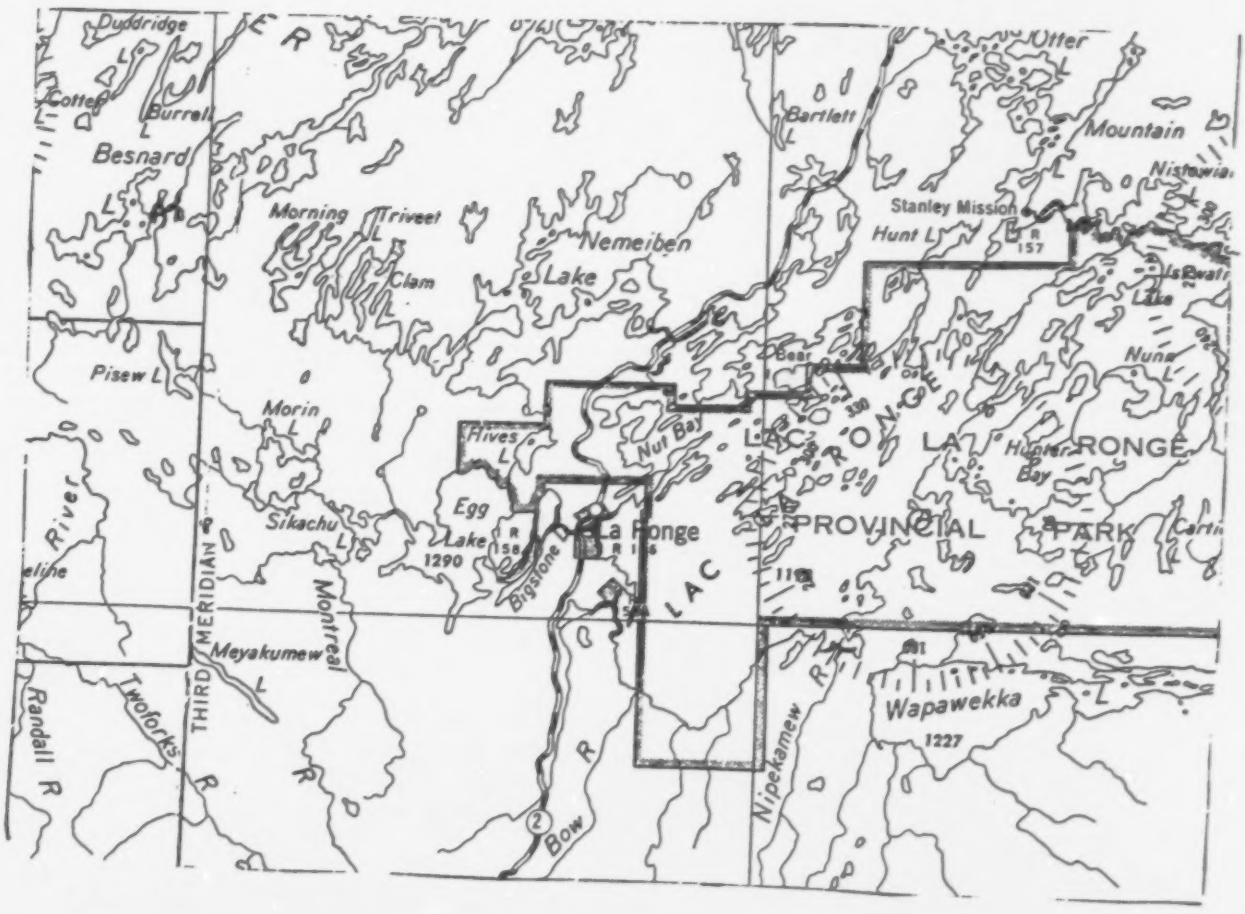
AREA REPORTS

The following section consists of small reports on the seven areas that were investigated for crayfish productivity. Each area is described, tested, and analyzed for its commercial potential. There are approximately 750 trap sets accounted for in the following pages.

*NOTE: Crayfish size refers to the distance from the acumen (or rostum) to the telson (tip of nose to end of tail).

Figure 1.3

Map of the La Ronge Region (trapped areas in red)



Weyakwin and Montreal Lakes lie approximately 109 km south of La Ronge.

REPORT ON THE MONTREAL RIVER - LA RONGE LAKE AREA

1. Description of the Area (see figure 1.4)

The Montreal River drains into La Ronge Lake about 4 km east of Bigstone Lake. The river itself is very rocky, and for the most part is not trappable due to the fast flowing water and rapids. The small bay into which the river flows has a silty or muddy bottom with abundant vegetation found throughout. As the water moves out into the lake the shoreline becomes rocky and plant growth diminishes.

There is a short narrows approximately 1 km downstream from the river's mouth. This narrows is about 150 m. wide and it is here that the river water first begins to mix with the colder lake water. The shoreline (which is composed of gravel and silt) falls quite sharply to an average channel depth of approximately 12 ft. The bottom is hard and is composed of small rock material. Even though the total length of the narrows is only 200 m. it is described because this particular area produced the largest crayfish as well as the highest productivity.

Once past this channel, however, the lake is again rocky with the occasional sandy and swampy area to be found.

2. Preliminary Predictions of Productivity

The reef areas in front of town were considered to have positive potential. This prediction could be attributed to the presence of moving water and ample shoreline vegetation. The channel area appeared to be an unlikely location for a productive crayfish population.

3. Data

DATE	FISHING METHOD	EFFORT	CRAYFISH CAPTURED	AV. SIZE
Aug. 18	Trapping	30 traps	24	8.0 cm
Aug. 19	Trapping	30 traps	38	8.0 cm
Aug. 20	Trapping	30 traps	0	n/a
Aug. 21	Trapping	50 traps	34	7.5 cm
Sept. 4	Trapping	50 traps	41	7.5 cm

4. Description of Fishing Effort

Aug. 18 15 traps were set in the channel, parallel to shore in 6-12 ft. of water. 15 traps were set around the point in shallow, weedy water.

Aug. 19 One string of traps (5) caught over 50% of the crayfish. One trap had 7 crayfish in it. The traps set in shallow water caught only 4 crayfish.

All thirty traps were reset in the channel in lines making approximately 45 degree angles with the shore (6-12 ft. in depth).

Aug. 20 The majority of the catch was again accounted for by only a few traps. One trap had 14 crayfish in it. Many traps were empty, however the size was very favourable. All thirty traps were moved into the bay and set along the boundaries of weed growth on a muddy bottom.

Aug. 21 No crayfish at all were captured. The thirty traps were reset in the narrows as before. 20 more traps were set across the narrows in the same depth of water. The 20 traps set across the channel produced only a few crayfish, while the majority of the catch was again accounted for by a few traps out of the thirty.

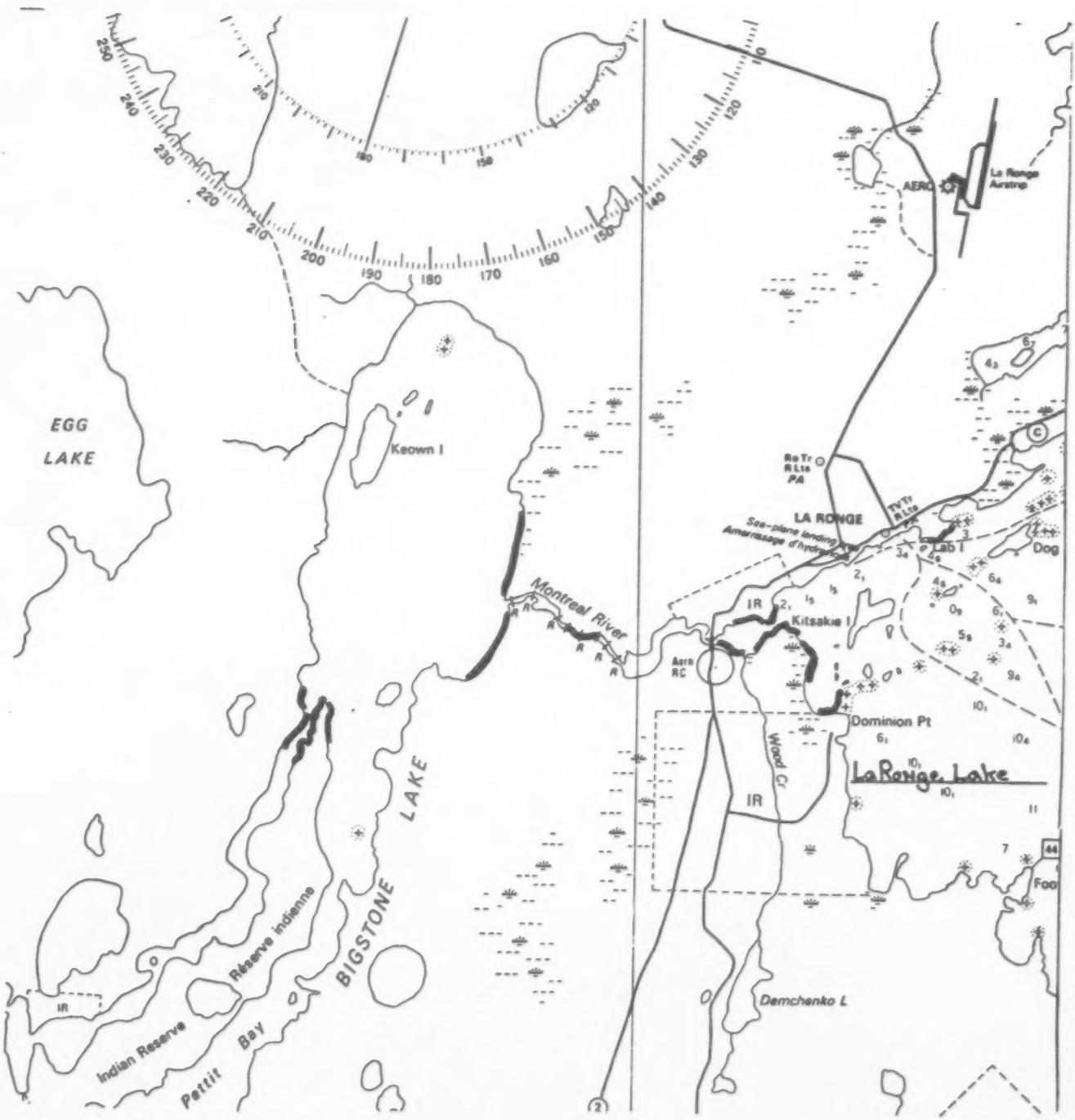
Sept. 4 30 traps were set in the channel in lines arranged perpendicular to the shoreline (6-15 ft. of water) 20 traps were set around rocky points about 2 km down the shoreline (2-8 ft. of water). The channel-set traps again accounted for over 70% of the catch. No variance in productivity was found with increasing depth.

5. Extent of Potential Crayfish Productive Habitat

Relatively speaking, the narrows represent crayfish 'productive' habitat. However, the size of the 'productive' area (approximately 3 football fields) is too small to be a commercial operation. The shoreline to the south of the narrows (which extends towards the Potato River area) contains crayfish but on a very limited scale. The shoreline on the north side of the narrows (which extends eastward) represents a similar situation. The reef areas offshore produced practically no crayfish.

Figure 1.4

Map of Bigstone Lake-Montreal River-La Ronge Lake
(trapped areas in red)



REPORT ON THE BIGSTONE-EGG LAKE AREA

1. Description of Area (See figure 1.4)

Bigstone Lake is predominantly shallow with much of the lake bottom covered by only 7-12 ft of water (yearly water levels can fluctuate as much as 15-20 inches). Weed growth is extensive and by August parts of the lake become almost impassable by boat. The bottom of the west side of the lake, (where Egg Lake drains into Bigstone Lake) is covered almost exclusively with black ooze and plant growth is dense. The water is extremely murky. On the east side of the lake (where the Montreal river drains Bigstone Lake into La Ronge Lake), the shoreline consists of extremely rocky areas interspersed with sandier areas. Plant growth is limited and the water appears clearer.

The lower Montreal River (which drains Hall Lake, Egg Lake, and Bigstone Lake), offers some of the warmest summer water temperatures in the area. Average July-August temperatures usually exceed 22 degrees C.

Bigstone Lake is approximately seven km. from La Ronge by road. Egg Lake is eight km. up the river from Bigstone Lake by boat.

2. Preliminary Predications of Productivity

The rocky shoreline on the east side of the lake appeared to be ideal crayfish habitat. The west side also seemed to have trappable areas. Commercial fishermen reported the presence of occasional crayfish caught intheir nets, and many La Ronge locals attested to their presence in the Lake.

3. DATA

DATE	FISHING METHOD	EFFORT	CRAYFISH CAPTURED	AV. SIZE
Aug. 4	Night Fishing	2 men x 1 hr	72	7.0 cm
Aug. 15	1½" mesh gilnet	24 hour set	0	n/a
Aug. 22	Traps	55 traps	18*	8.0 cm
Aug. 23	Traps	55 traps	14**	8.0 cm

* (.33 crays/trap)
**(.25 crays/trap)

4. Description of Fishing Effort

Aug. 4 The east shoreline of the lake was fished. 20-30% of sighted crayfish escape because of their good mobility. The larger crayfish are often seen crawling in deeper water (3-6 ft.), which inhibits easy capture. (This is also indicated by the average size, compared with that of trapping.)

Aug. 15 The net was set at approximately a thirty degree angle to the shoreline in depths sloping from 3-6 ft. This was unsuccessful in capturing crayfish and was very entangled in suspended debris by morning.

Aug. 22 35 traps were set on the east shore in depths ranging from 2-5 ft. 20 traps were set on the west side (including the river) at the same depth. The west side traps caught only 2 crayfish.

Aug. 23 35 traps were set in parallel lines at depth increments of approximately 2-3 ft. (down to a maximum depth of approximately 12 ft.). These were set again on the east shore. The 20 traps on the west side were treated in the same fashion. This did not improve the catch. No depth differentiation was found.

5. Extent of Potential Crayfish Productive Habitat

Although no areas on this body of water turned out to be 'productive' commercially, relatively speaking - the rocky, sandy areas represented the crayfish productive habitat. Bigstone Lake contains about 2-3 km of this particular type of shoreline. Egg Lake is a much larger body of water with similar characteristics, therefore offering much more rocky shoreline. However, the productivity on Egg Lake can be expected to be no greater than that of Bigstone Lake.

Muddy and weedy areas produced no crayfish at all.

6. Difficulties Encountered

Depending on the direction of prevailing winds, weedy debris buildup would result along the shorelines. In some areas this buildup was so extensive that trapping was impossible.

REPORT ON THE MOUNTAIN-DROPE LAKE AREA

1. Description of Area (see figure 1.5)

Mountain Lake, which drains into Drope Lake on the Churchill River system lies just below Otter Lake. Both Mountain and Drope Lakes are relatively small and have definite riverlike characteristics. Shorelines in this area consist exclusively of bedrock formations ranging from vertical cliffs to boulder beaches. Sandy areas are rare. Although many of the shoreline rocks are covered with algae growths, weed beds are found only in sheltered bays and inlets surrounding the outside perimeters of the lakes. In most areas the bottom slopes down fairly quickly so traps have to be set relatively close to shore (15-20 ft.), in order to stay under 12 ft. of water.

The water on the Churchill River system is clear (it tends to get slightly murky as algae growths flourish in late summer), and cool. Midsummer temperatures would rarely reach 18 degrees C.

Mountain Lake is 90 km. from La Ronge by road. From there it is approximately 5 km. by boat to Drope Lake.

2. Preliminary Prediction of Productivity

Locals in the area reported an abundance of crayfish around areas of fast flowing water. Due to the presence of all types of rocky areas, the potential for a high crayfish productivity seemed good.

3. Data

DATE	FISHING METHOD	EFFORT	CRAYFISH CAPTURED	AV. SIZE
Aug. 24	Trapping	57 traps	48*	6.5 cm
Aug. 25	Trapping	57 traps	63**	6.5 cm
Sept. 1	Trapping	15 traps	22***	6.0 cm
Sept. 1	Nightfishing	Observation	****	≈5.0-6.0 cm

* (.84 crays/trap)
** (1.1 crays/trap)
*** (1.5 crays/trap)
**** (≈3 crays/trap)

4. Description of Fishing Efforts

Aug. 24 30 traps were set at varying depths on gently sloping rock beds (consisting of boulders of all sizes). 27 traps were set in 8-12 ft. of water below abruptly rising shoreline. The traps set beside the steeper slopes accounted for over 70% of all crayfish caught.

Aug. 25 All 57 traps were set in 8-12 ft. of water below abruptly rising shoreline. The 27 more productive traps from the night before were not moved. The productivity of those traps did not fall.

Sept. 1 All 15 traps were set in the same location as the previous two sets of 27 traps on Aug. 24 and 25. The productivity did not fall, but rather rose.

Sept. 1 The rocky cliffs were observed at night using night-fishing methods. As indicated, approximately 3 crayfish could be seen clinging to the rock faces/meter of shoreline. The size, however, was disappointingly small.

5. Extent of Potential Crayfish Productive Habitat

If the word 'productive' is again used in the relative sense, then the rocky, steeply-sloping shorelines represented crayfish productive habitat. However, the shallower areas also produced crayfish, yet at a reduced rate. The limiting factor for bothareas seemed to be the presence of flowing water. As the traps were moved away from flowing water, the productivity began to drop.

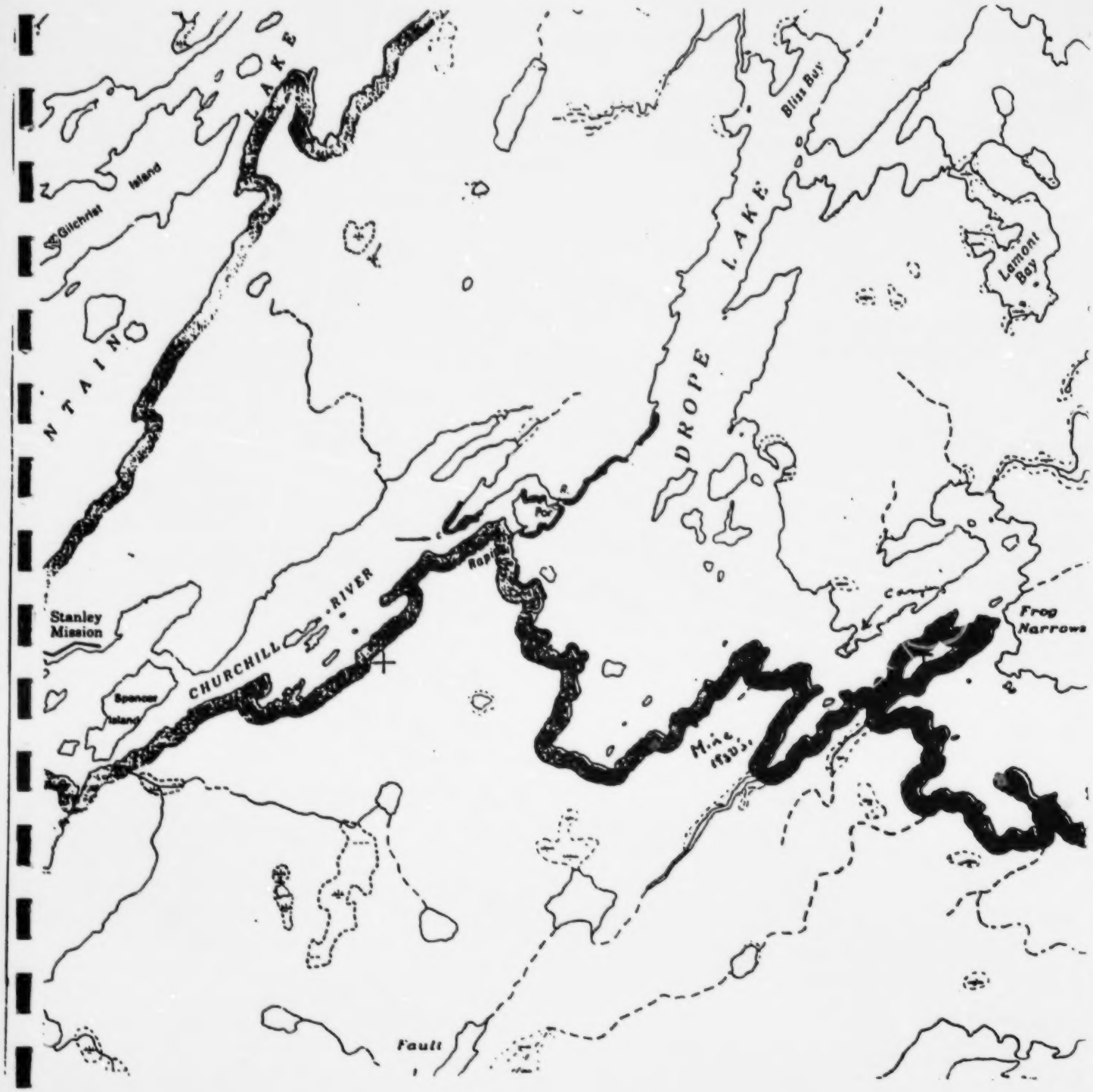
As mentioned above, the lakes which make up the Churchill River system have definite riverlike characteristics. As such, many km. of the desired shoreline could easily be found.

6. Difficulties Encountered

When trapping in deeper water off sharply-rising shorelines, traps had to be set very close to shore. Retrieval of buoys became difficult if on-shore winds developed overnight. Anchors and traps frequently became caught on rocky bottom structures. However, no equipment was lost.

Figure 1.5

Map of Mountain Lake-Drope Lake (trapped areas in red)



REPORT ON THE NEMEIBEN RIVER-LA RONGE LAKE AREA

1. Description of Area (see figure 1.6)

Nemeiben River runs into the northern arm of La Ronge Lake about 33 km. north of La Ronge. The river itself is fairly small and does not represent a large flow of water. Muddy areas can be found, however the majority of the river bed is composed of rocks and boulders of various sizes. Besides the muddy areas, vegetation is limited to the fringes of the river. The depth of the lower part of the river is fairly uniform (3-7 ft.) and, as such, it represented a possible trapping area.

The particular arm of La Ronge Lake (Wadin Bay) into which the river flows is basically a very large bay with islands of all sizes scattered about within it. The shoreline is composed mainly of rocks and boulders with sandier beach areas interrupting this every few kms. Weeds and other types of large vegetation are again found mainly in sheltered bays and inlets. The shoreline dips fairly gradually making trap setting easy.

The water in the river and in the bayis fairly clear, although most rocks have algae growths on them (especially in the river). The water is cool, summer temperatures would rarely exceed 18 degrees C.

2. Preliminary Predications of Productivity

La Ronge locals and Wadin Bay cabin owners reported the presence of very large crayfish in the area. Some scuba divers also testified to the existence of an abundant crayfish population in the Nemeiben River.

3. Data

DATE	FISHING METHOD	EFFORT	CRAYFISH CAPTURED	AV. SIZE
Aug. 3	Nightfishing	2 menx45 min.	37	7.0 cm
Aug. 27	Trapping	57 traps	28	7.5 cm
Aug. 28	Trapping	57 traps	34	7.5 cm

4. Description of Fishing Effort

Aug. 3 The Wadin Bay area was nightfished in an attempt to assess the crayfish population there. Beaches proved to be completely unproductive as only occasional young crayfish were found. Rockier areas adjacent to these beaches held crayfish in the order of 2 crays/m. These again were hard to catch and most were too small to be valuable.

Aug. 27 30 traps were set at right angle so the current at various locations and depths in the Nemeiben River. Both rocky and muddy areas were trapped.

27 traps were set around a rocky point on La Ronge Lake approximately 1 km. from the river's mouth. Depth of sets ranged from 3-10 ft.

Aug. 28 15 traps were reset in the river over rock areas. Muddy areas caught no crayfish. The 27 traps set around the point accounted for over 70% of the previous nights' catch. These traps were reset in the same spot with 15 more traps set in the surrounding areas.

5. Extent of Potential Crayfish Productive Habitat

In this particular area, the river turned out to be no more productive than the shorelines of neighboring La Ronge Lake. The word 'productive' does not correspond with the actual numbers of crayfish that were captured, however, that given productivity should be attainable for that arm of the lake. This, of course, represents many miles of shoreline.

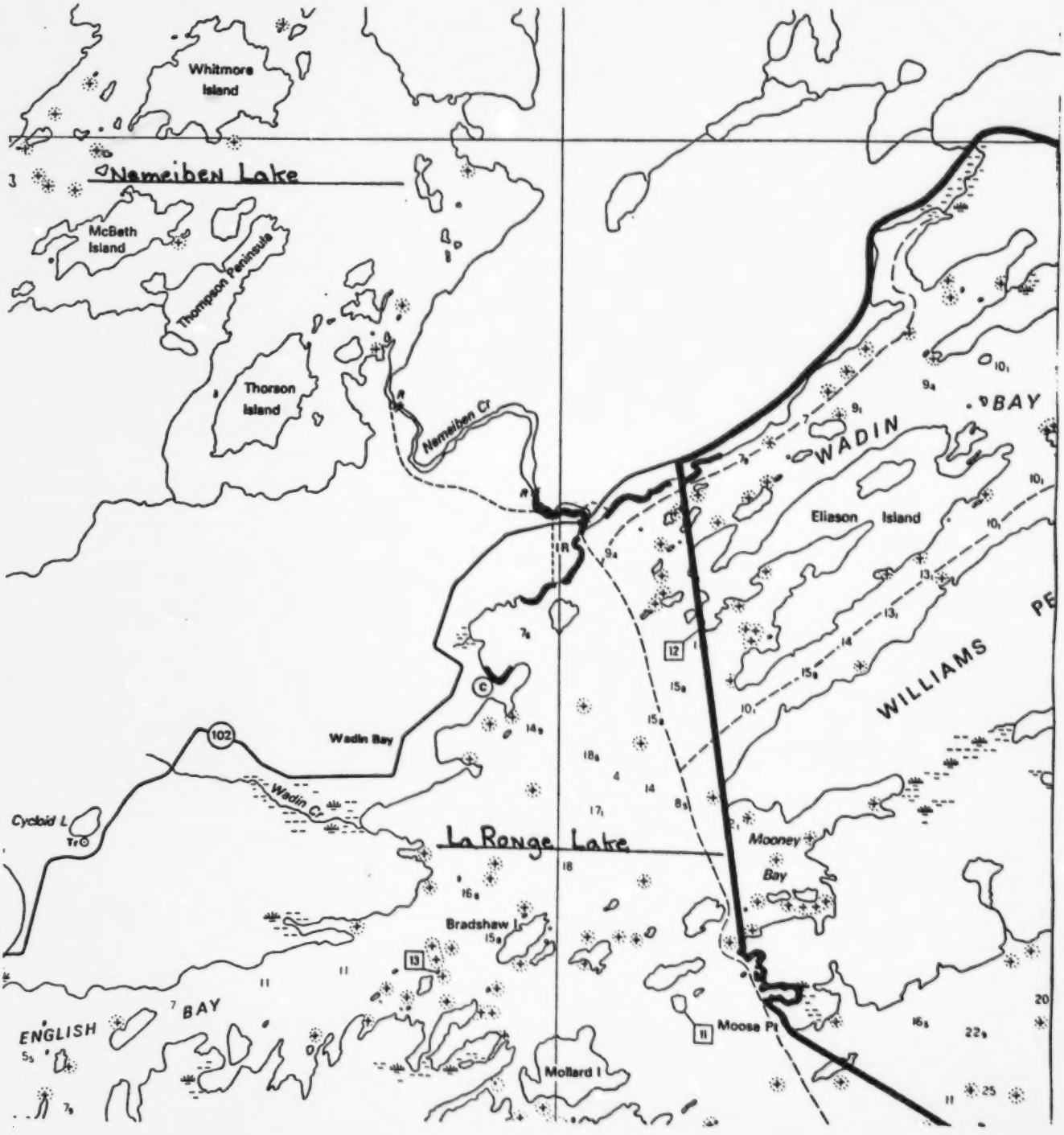
One can expect, and experience has shown, that if crayfish are found below the river joining two lakes, that in all probability, they will be found above it as well. This assumption is, of course, habitat-dependent.

6. Difficulties Encountered

When trapping on a lake the size of La Ronge Lake, trap retrieval can become extremely difficult if onshore winds develop. Even though this area is somewhat sheltered, problems can still arise. On such occasions traps will have to be left in the water until winds die down.

Figure 1.6

Map of Nemeiben River-La Ronge Lake (trapped areas in red)



REPORT ON THE POTATO RIVER-LA RONGE LAKE AREA

1. Description of the Area (see figure 1.7)

Potato River runs into the south-eastern arm of La Ronge Lake approximately 10 km. south of La Ronge. Potato Lake itself is a very small and shallow lake which supports extensive weed and wild rice growth. The water warms up considerbly in summer and is very dark and murky in appearance. The river is small and consists of a few sets of rapids followed by a slow-flowing channel which extends approximately 1 km. before it drains into La Ronge Lake. The channel bed is covered by 2-7 ft. of water and is rocky for the most part.

The bay into which the river flows is a shoal area with maximum depths not exceeding 25 ft. Similar to the Wadin Bay area, the shoreline is composed of rocks and boulders with sandier beach areas interrupting this every few kms. The shorelie also dips very gradually, but unlike Wadin Bay there is a string of reefs and shallow water found about 2 km. offshore. Vegetation is sparse and found only in sheltered areas. This region is very unprotected and is subject to wave buildup in anywhere from 23-28 km. of open water. As in most other parts of La Ronge Lake, the water is clear and cool.

Potato Bay is 11 km. from La Ronge by boat and about 25 km. from La Ronge by road.

2. Preliminary Predictions of Productivity

This area has been a valuable commercial fishing ground for many years. Some fishermen reported that toward fall (late August), they had observed crayfish moving around the reef areas offshore. During this time crayfish occasionally get tangled in their nets. As mentioned above, this area is very rocky and shallow, so once again things appeared to be promising.

3. Data

DATE	FISHING METHOD	EFFORT	CRAYFISH CAPTURED	AV. SIZE
Aug. 8	Nightfishing	Observation	n/a	n/a
Sept. 6	Trapping	55 traps	28	6.5 cm
Sept. 7	Trapping	55 traps	12	7.5 cm

4. Description of Fishing Effort

Aug. 8 The Potato Lake area was nightfished in an attempt to assess the crayfish population there. However, due to the excessive weed growth that is found throughout the lake, this proved to be all but

impossible. Potato Lake crayfish are also very hard to see because of their pitch black colour and the murky water in which they live.

Sept. 6 25 traps were set in the rocky Potato River channel in depths ranging from 2-7 ft. 10 traps were set in the bay on both sides of the river mouth in 4 ft. of water. 20 traps were set 5 km. down the shoreline (south) in depths ranging from 2-20 ft.

Sept. 7 The 25 river-set traps caught over 80% of the crayfish captured. However, they were all small. 35 traps were moved to the reef areas approximately 2 km. offshore. The 20 traps set south of the river were reset in the same location.

5. Extent of Potential Crayfish Productive Habitat

The Potato River does not represent a commercially productive crayfish area because of the size and number of crayfish captured. Trappable areas are also limited to the rocky channels above and below the rapids.

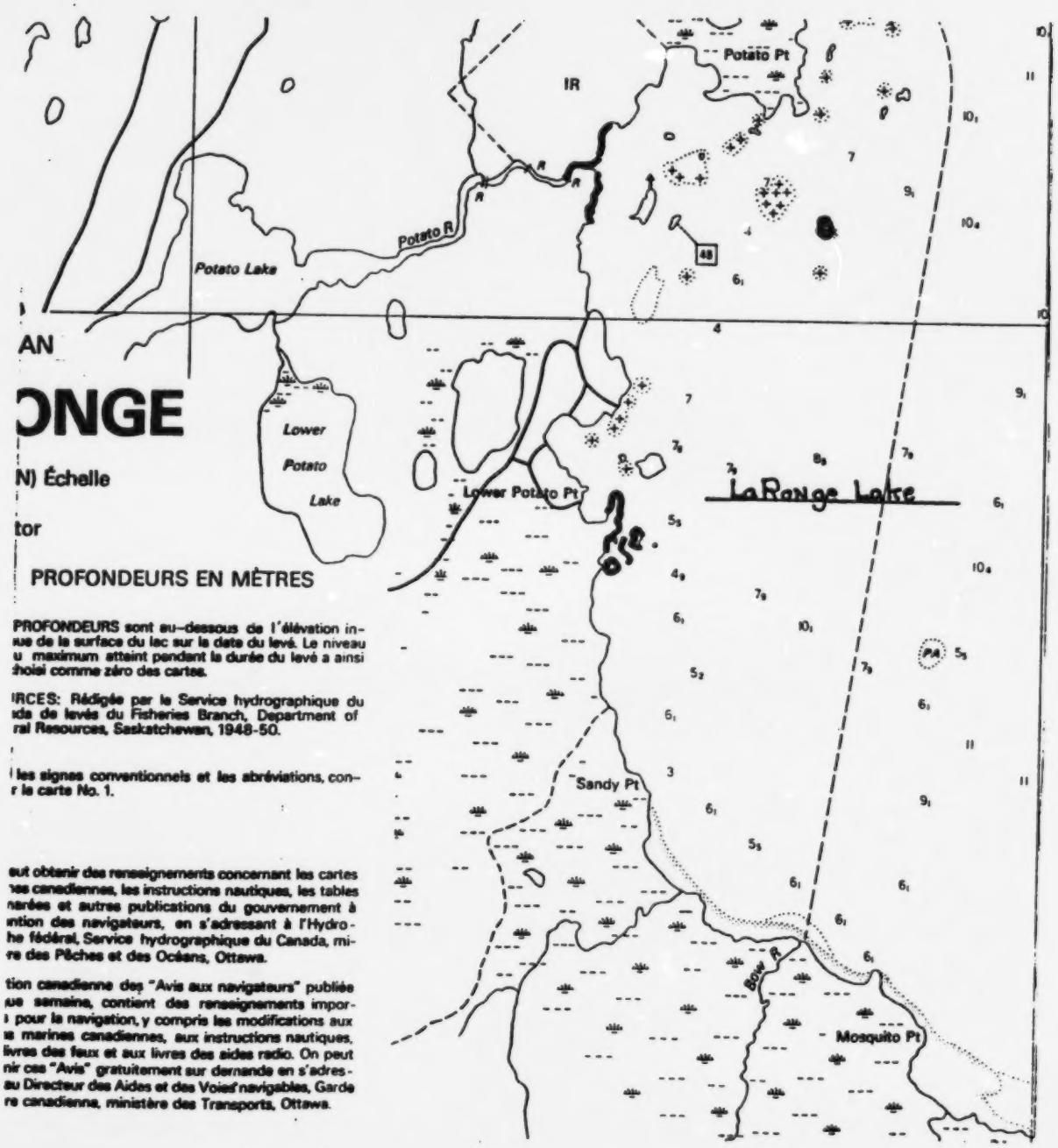
Potato Bay on La Ronge Lake offers a huge trappable area, however the productivity was extremely low even though the size was somewhat improved.

6. Difficulties Encountered

As already mentioned, this particular area of La Ronge Lake is very open and susceptible to the effects of bad weather. The reef areas would be all but impossible to trap in even moderately windy conditions.

Figure 1.7

Map of Potato Lake-Potato River-La Ronge Lake
(trapped areas in red)


Potato Pt
IR
Potato R
Potato Lake
Lower
Potato
Lake
Lower Potato Pt
LaRonge Lake
Sandy Pt
Bow R
Mosquito Pt
AN
ONGE
N) Échelle
tor
PROFONDEURS EN MÈTRES
PROFONDEURS sont au-dessous de l'élévation in-
ue de la surface du lac sur la date du levé. Le niveau
u maximum atteint pendant la durée du levé a ainsi
hoisi comme zéro des cartes.
IRCES: Rédigée par le Service hydrographique du
da de levés du Fisheries Branch, Department of
ral Resources, Saskatchewan, 1948-50.
les signes conventionnels et les abréviations, con-
r la carte No. 1.
ut obtenir des renseignements concernant les cartes
es canadiennes, les instructions nautiques, les tables
narées et autres publications du gouvernement à
ntion des navigateurs, en s'adressant à l'Hydro-
he fédéral, Service hydrographique du Canada, mi-
re des Pêches et des Océans, Ottawa.
tion canadienne des "Avis aux navigateurs" publiée
ue semaine, contient des renseignements impor-
pour la navigation, y compris les modifications aux
s marines canadiennes, aux instructions nautiques,
livres des feux et aux livres des aides radio. On peut
nir ces "Avis" gratuitement sur demande en s'adres-
au Directeur des Aides et des Voies navigables, Garde
re canadienne, ministère des Transports, Ottawa.

REPORT ON THE WEYAKWIN-MONTREAL LAKE AREA

1. Description of Area (map not available)

Weyakwin Lake is a fairly small lake which is bounded in part by sand, and in part by rocks and boulders. The east side of the lake has a predominantly rocky shoreline while the west side has numerous beaches. Vegetation is found only in a few sheltered areas, and weed growth is very limited.

Weyakwin Lake drains via the Weyakwin River into the north-western corner of Montreal Lake. Montreal Lake is a much larger, elongated body of water that lies on a north-south axis. However large it may be, Montreal Lake is shallow, and extensive weed growth occurs in all but the southern portions of the lake. The bottom of the lake is composed mainly of sand and silt so shore areas are easily stirred up. The Montreal Lake shoreline is even more unprotected than neighboring Weyakwin Lake.

Both Weyakwin and Montreal Lake are located approximately 105 km. south of La Ronge by road.

2. Preliminary Predictions of Productivity

Of all the areas that were checked, this was the only one where local residents said there were no crayfish, or at the very best, a small population. A Weyakwin Lake outfitter who had worked in the area for 10 years had never seen a crayfish. Several Montreal Lake fishermen who had been on the lake most of their lives had only seen a few crayfish in that whole period of time. We were told that in the river areas (Weyakwin and Montreal River), small populations might exist.

However bad it seemed, Weyakwin Lake was trapped for one night simply because the eastern shoreline appeared to be ideal for crayfish. The residents turned out to be right.

3. Data

DATE	FISHING METHOD	EFFORT	CRAYFISH CAPTURED	AV. SIZE
Sept. 10	Trapping	50 traps	0	n/a

4. Description of Fishing Effort

Sept. 10 50 traps were set along the eastern shoreline in depths ranging from 2-8 ft. (The river area was not trapped simply because its limited shoreline could not offer a commercially harvestable population even if crayfish were present.) As indicated no crayfish were caught so the traps

were pulled. Montreal Lake was not trapped for obvious reasons.

5. Extent of Potential Crayfish Productive Habitat

n/a

6. Difficulties Encountered

n/a

REPORT ON THE BESNARD LAKE AREA

1. Description of Area (map not available)

Besnard Lake is one of a string of shield* lakes (including Trivet, Clam and Nemeiben Lakes) which lie just south of the chain of lakes that comprise part of the Churchill River system (including Trout, Black Bear Island, and McIntosh Lakes). Besnard Lake is characteristically rocky with occasional sandy beaches and gravel areas, however, in the south-western arm of the lake (into which the Mercer River drains) plant growth is more abundant.

*The water is very clear and cold.

Besnard Lake is 142 km. from La Ronge by road.

2. Preliminary Predictions of Productivity

Some divers indicated that on more than one occasion they had observed crayfish along the shoreline of the government campground. Other locals also knew of the presence of crayfish but gave no indication of quality or quantity.

3. Data

DATE	FISHING METHOD	EFFORT	CRAYFISH CAPTURED	AV. SIZE
Sept. 11	Trapping	50 traps	22	7.0 cm
Sept. 11	Nightfishing	Observation	n/a	6.0 cm

4. Description of Fishing Effort

Sept. 11 25 traps were set in various rocky locations in the general area of the government campground (depths ranging from 2-10 ft.).

25 traps were set about 6 km. down the shoreline (in the south-western arm of the lake) in approximately the same depth range.

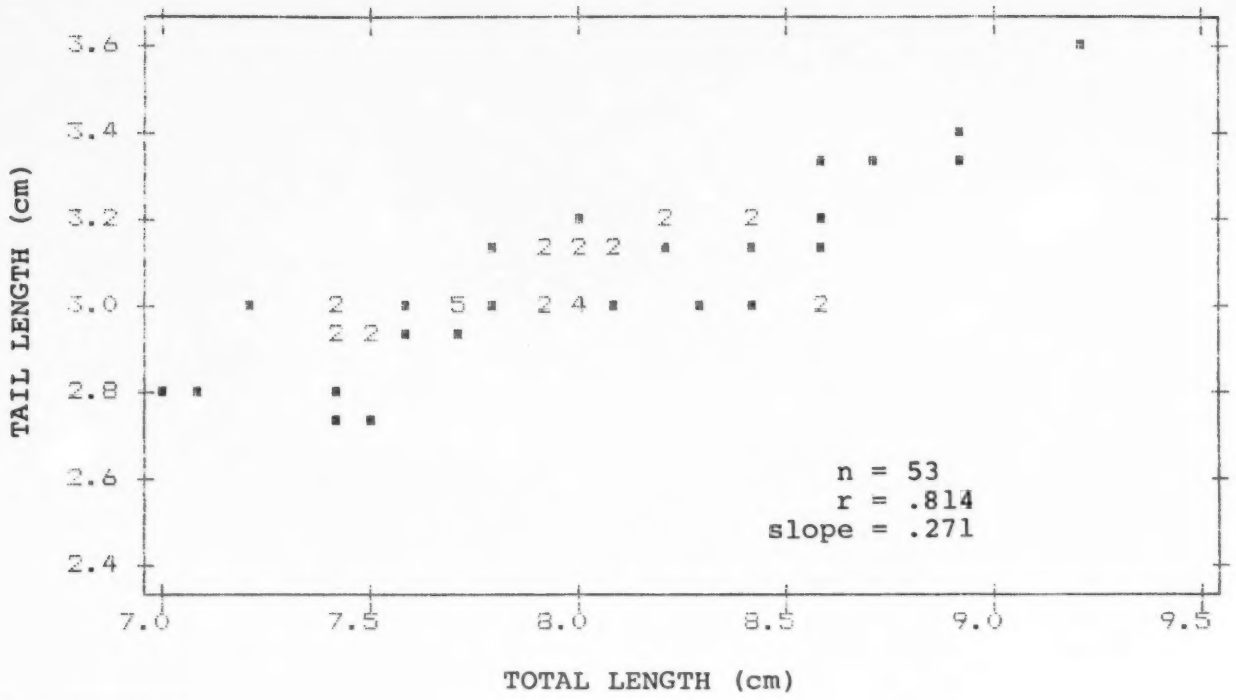
Production was very poor in both areas, consequently all the traps were pulled.

Sept. 11 Some islands were nightfished in order to assess the potential crayfish population. Steeply sloping rocky ledges or inclines had very few crayfish on them, while rocky beaches had 2 crayfish/meter. As indicated the majority of these were very small.

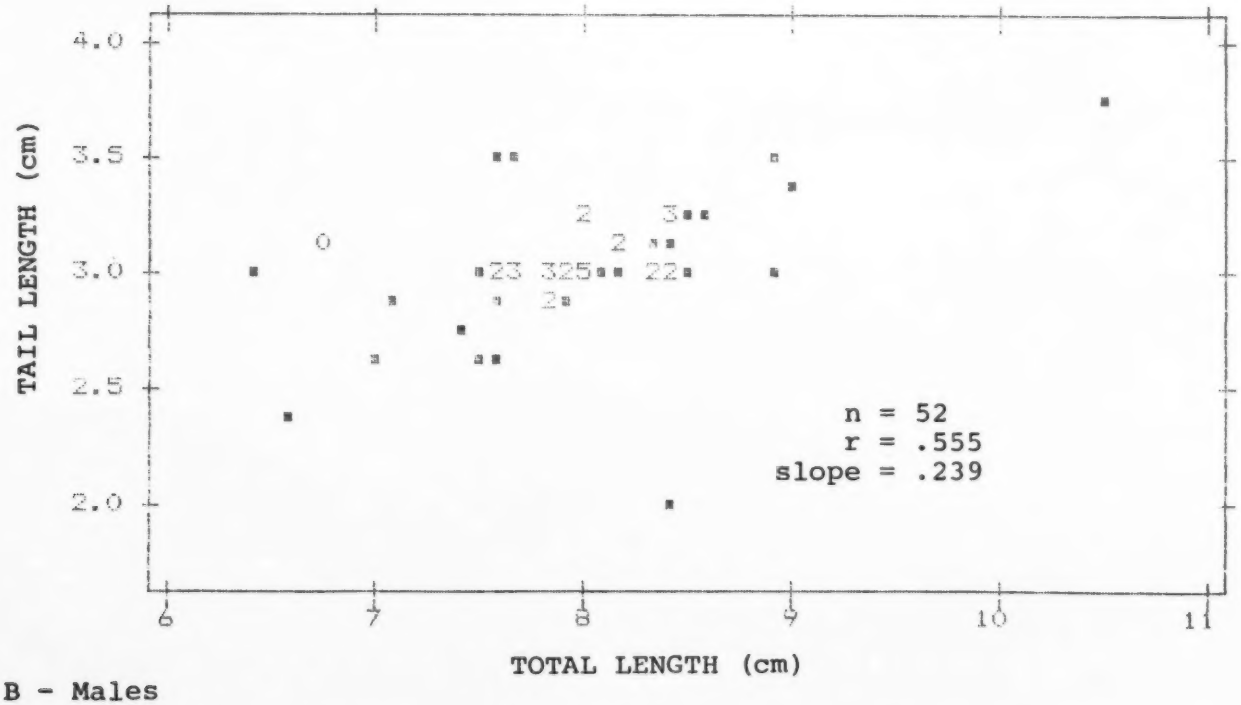
5. Extent of Potential Crayfish Productive Habitat

As in most northern lakes, the shoreline on Besnard Lake is uniformly rocky throughout much of its extent. This again implies that many kms of trappable shoreline can be found. However, the limiting factor is the size of the gap between the naturally occuring productivity and the productivity required to substantiate a commercial harvest.

APPENDIX II

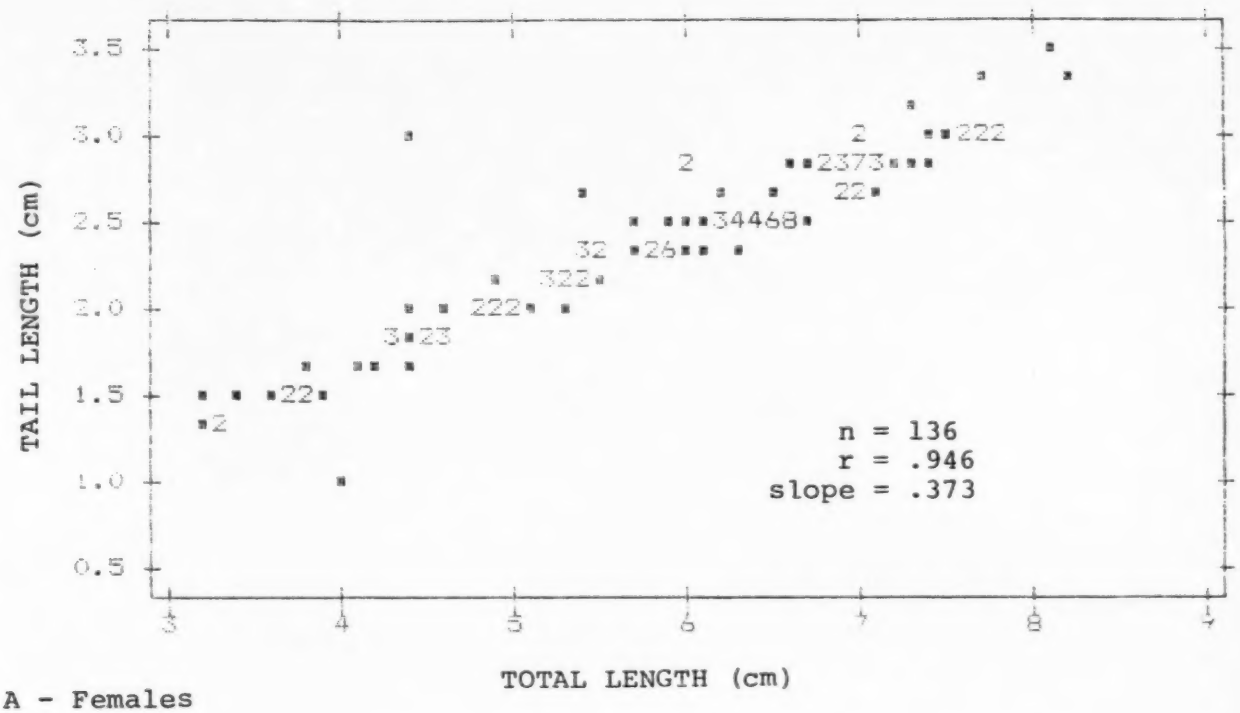


A - Females

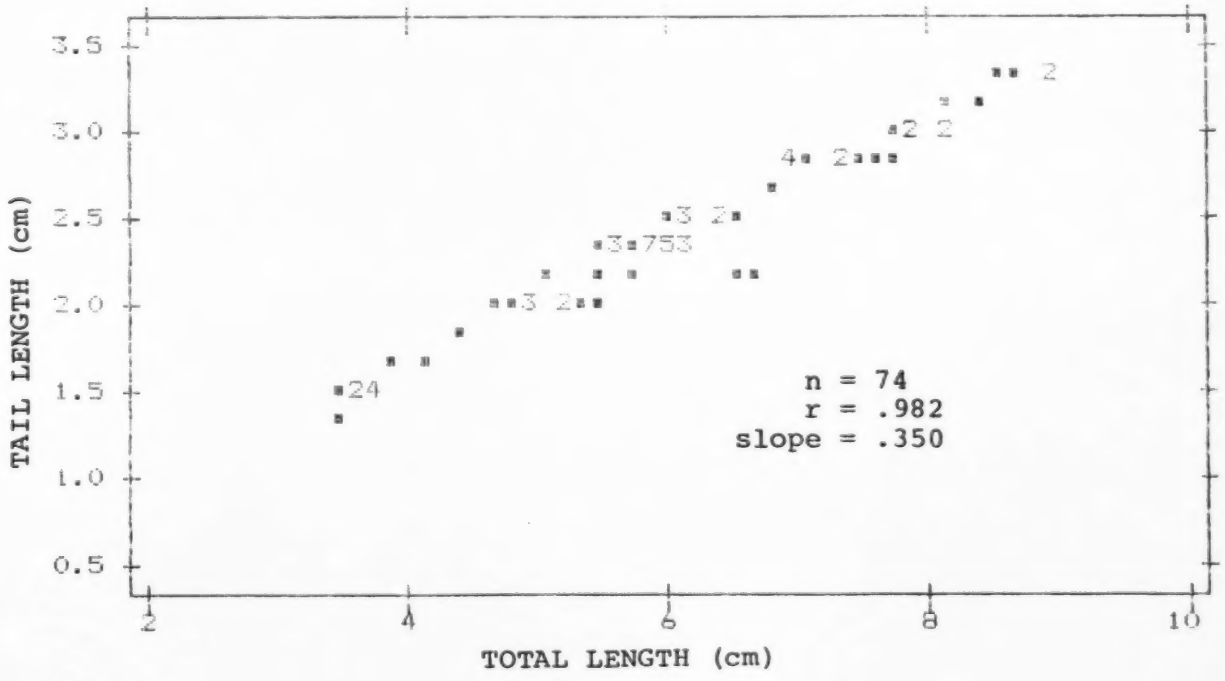


B - Males

Figure A-1 Relationships Between Tail Length and Total Length of Crayfish from Katepwa Lake.

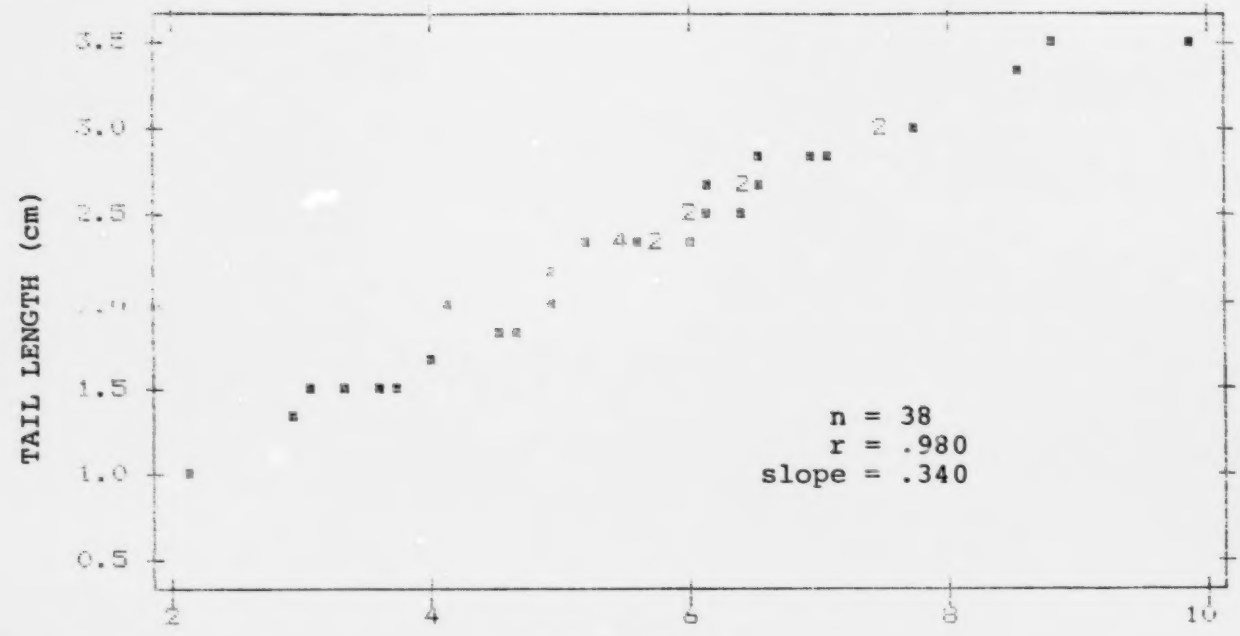


A - Females

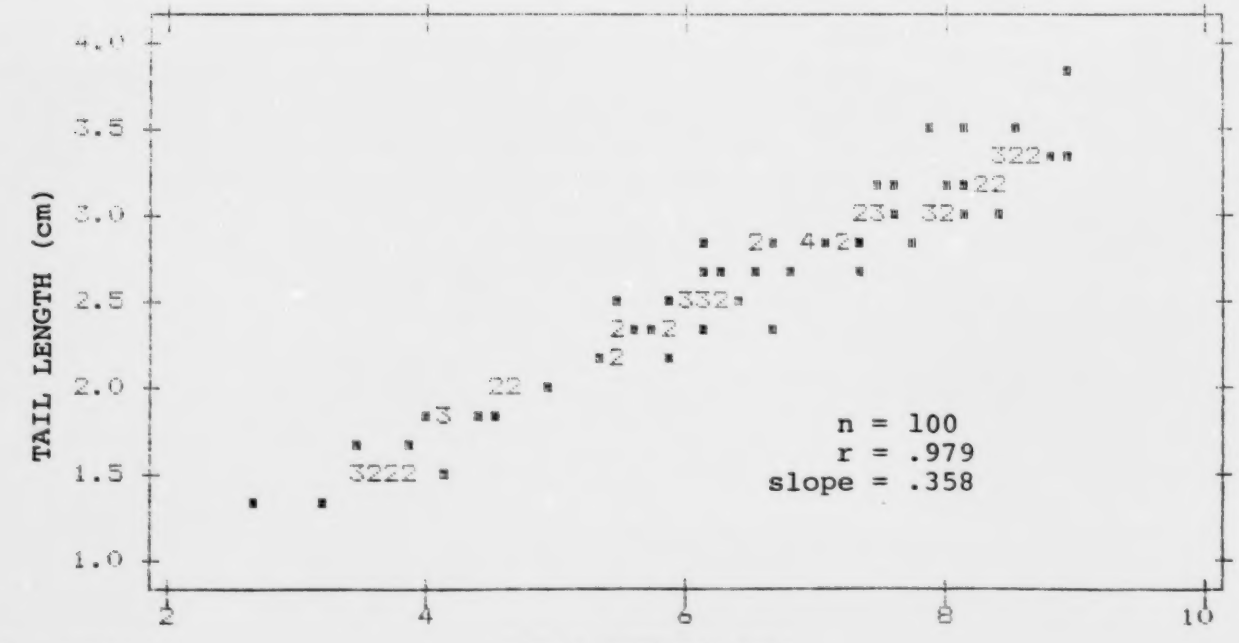


B - Males

Figure A-2 Relationships Between Tail Length and Total Length of Crayfish from Last Mountain Lake.

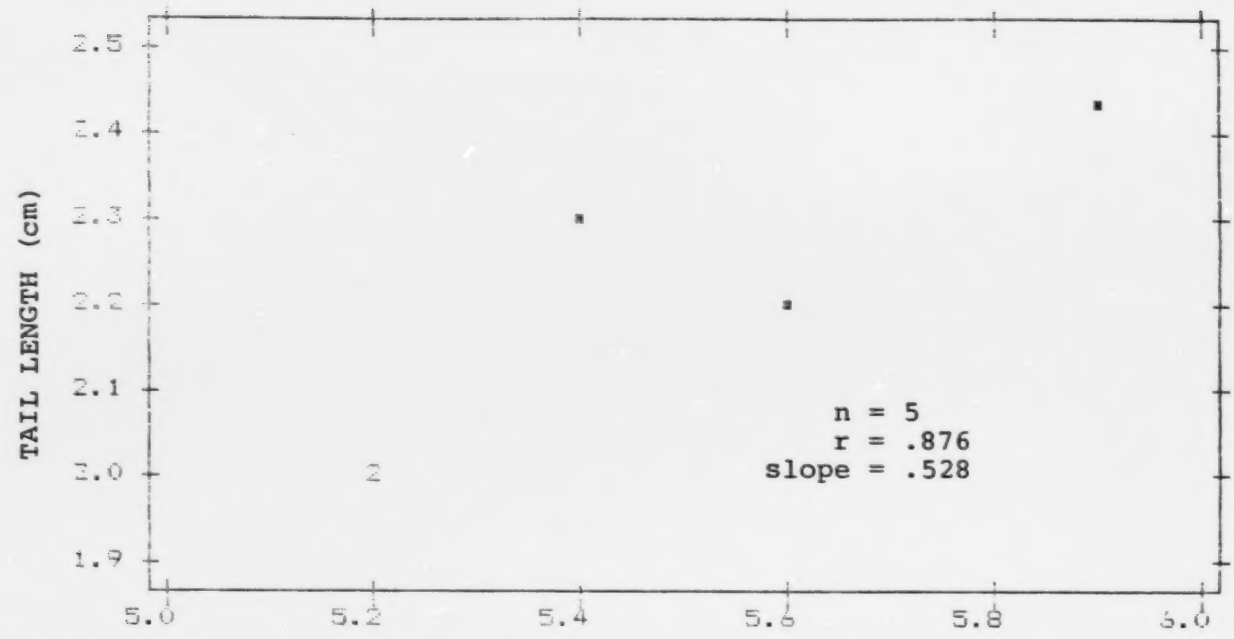


A - Females

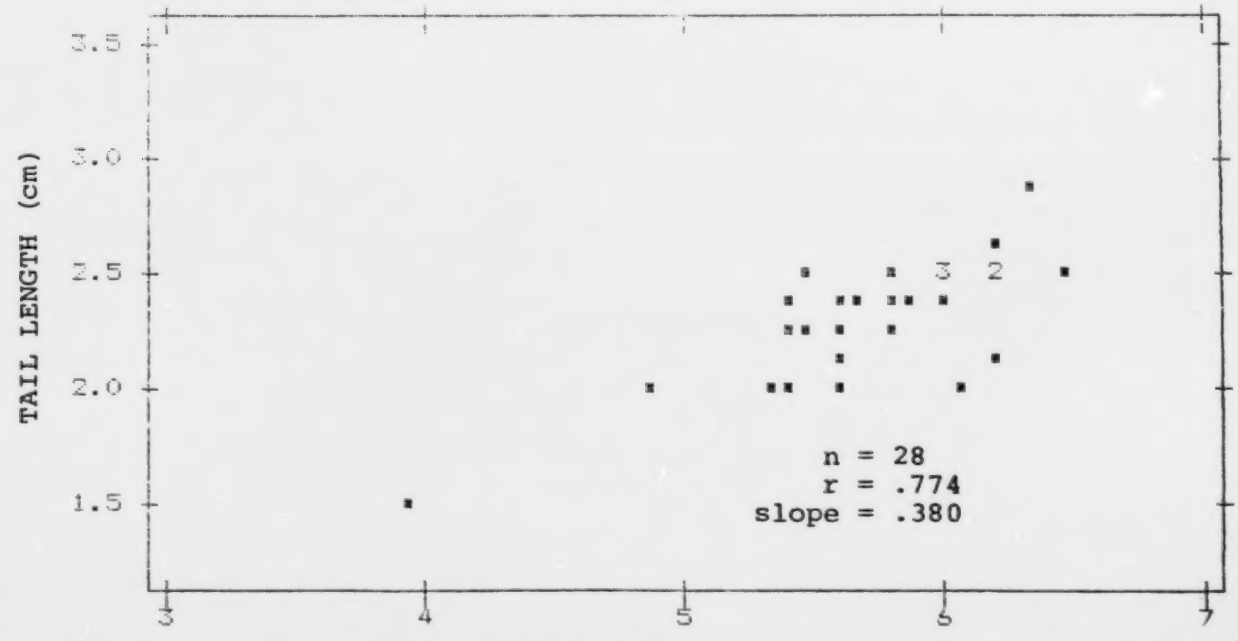


B - Males

Figure A-3 Relationships Between Tail Length and Total Length of Crayfish from the Saskatchewan River at Cumberland House.

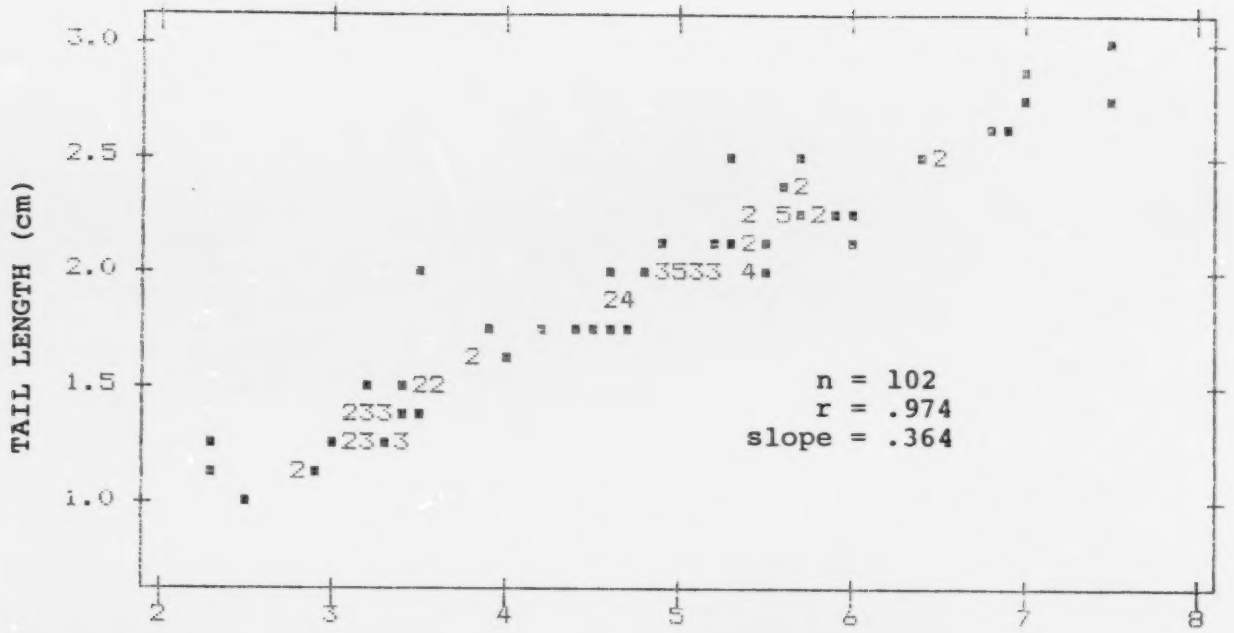


A - Females



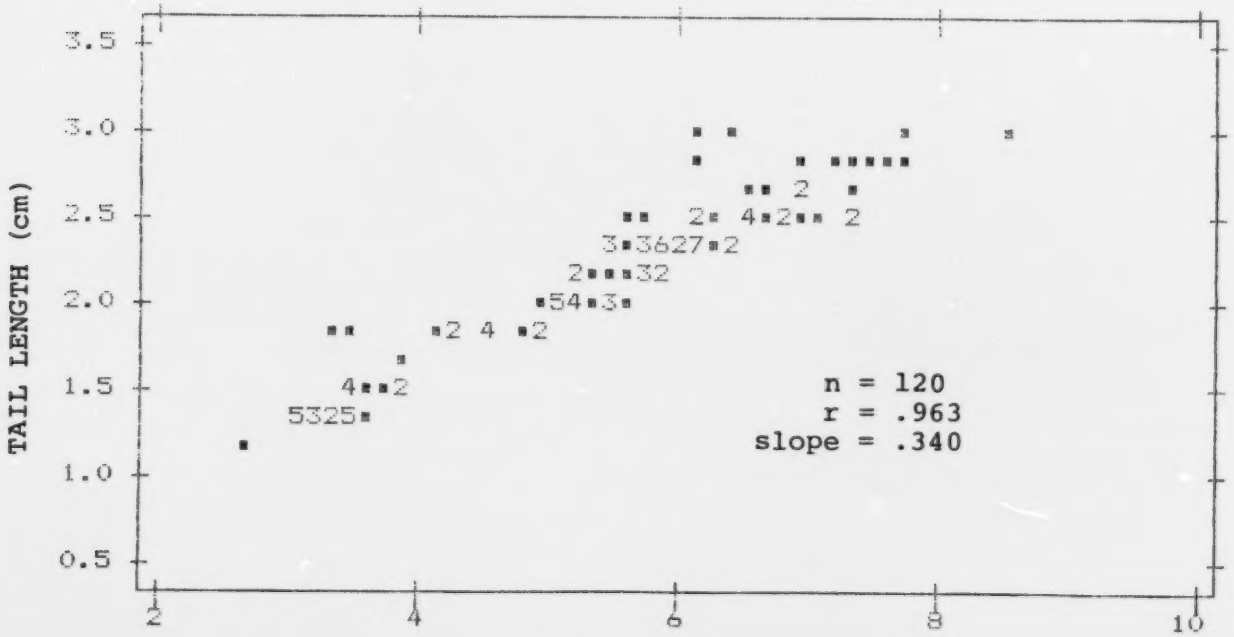
B - Males

Figure A-4 Relationships Between Tail Length and Total Length of Crayfish from Candle Lake.



A - Females

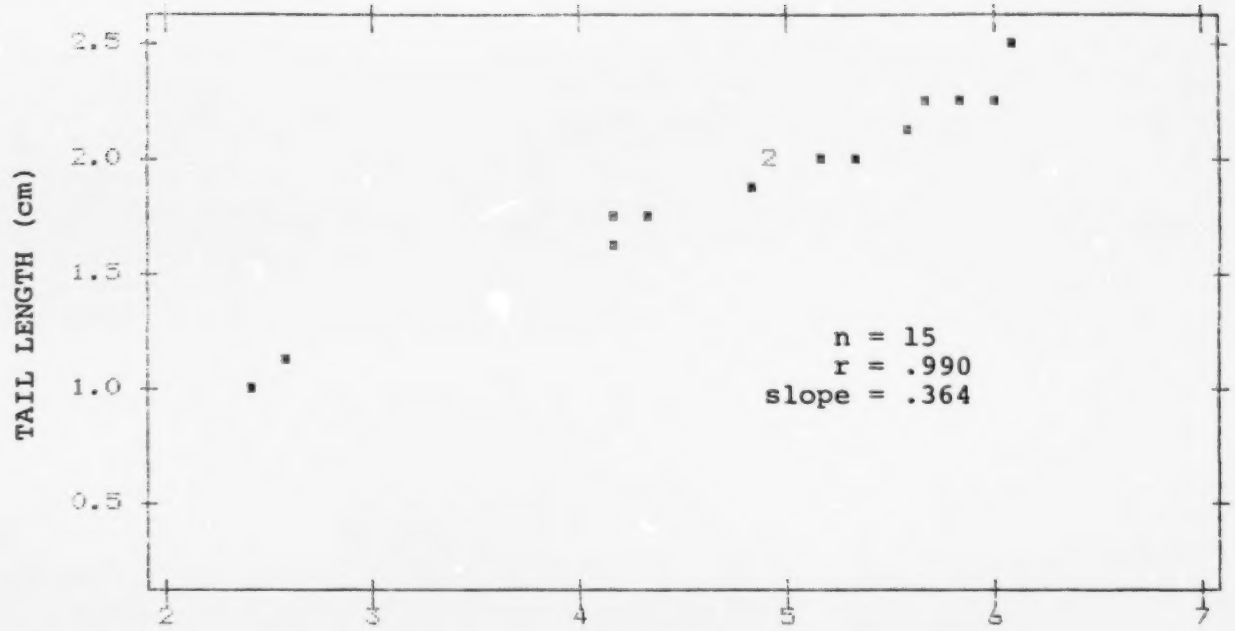
TOTAL LENGTH (cm)



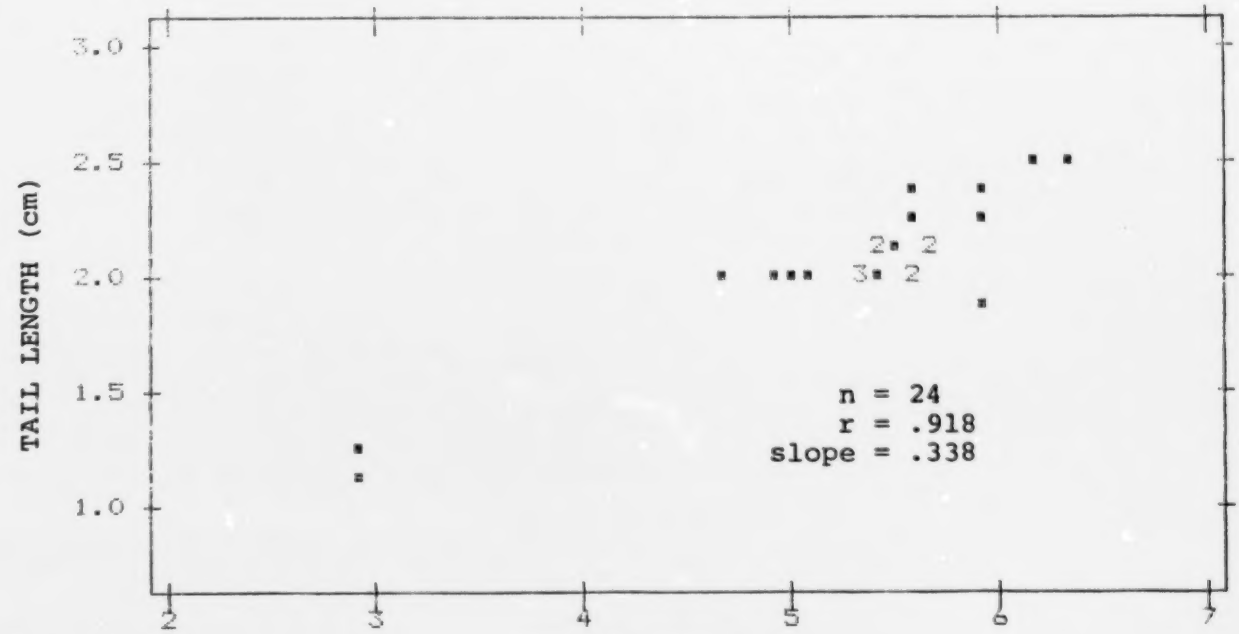
B - Males

TOTAL LENGTH (cm)

Figure A-5 Relationships Between Tail Length and Total Length of Crayfish from McBride Lake.

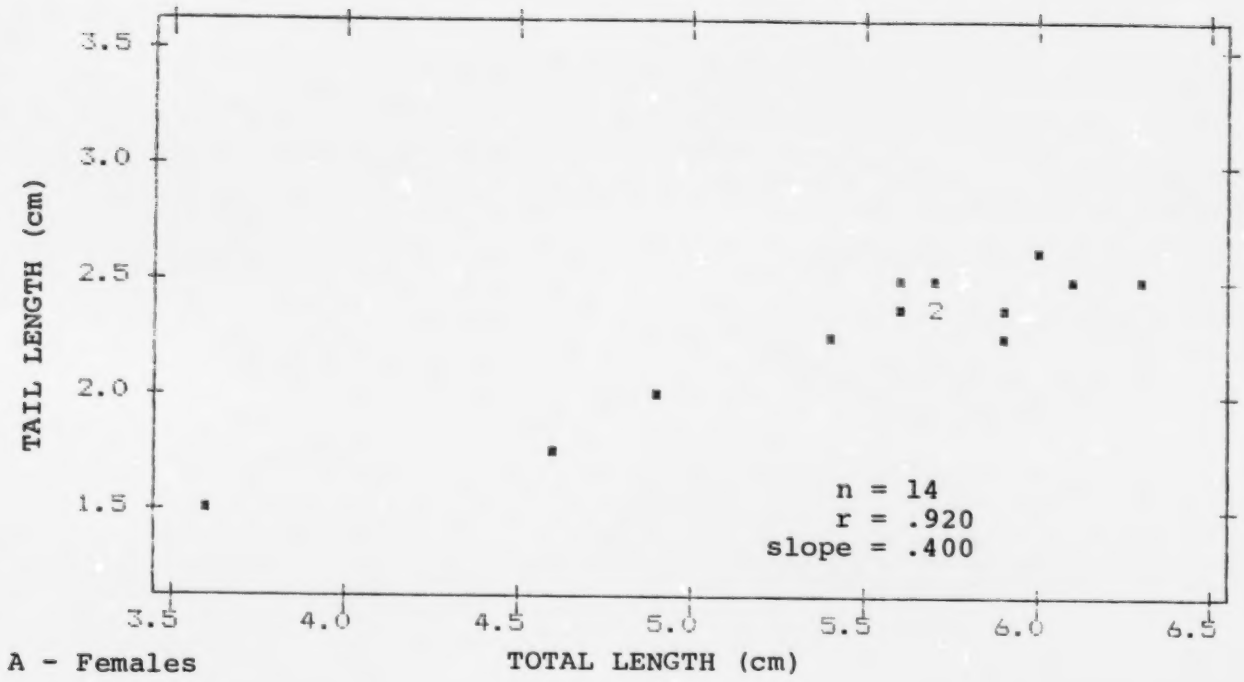


A - Females

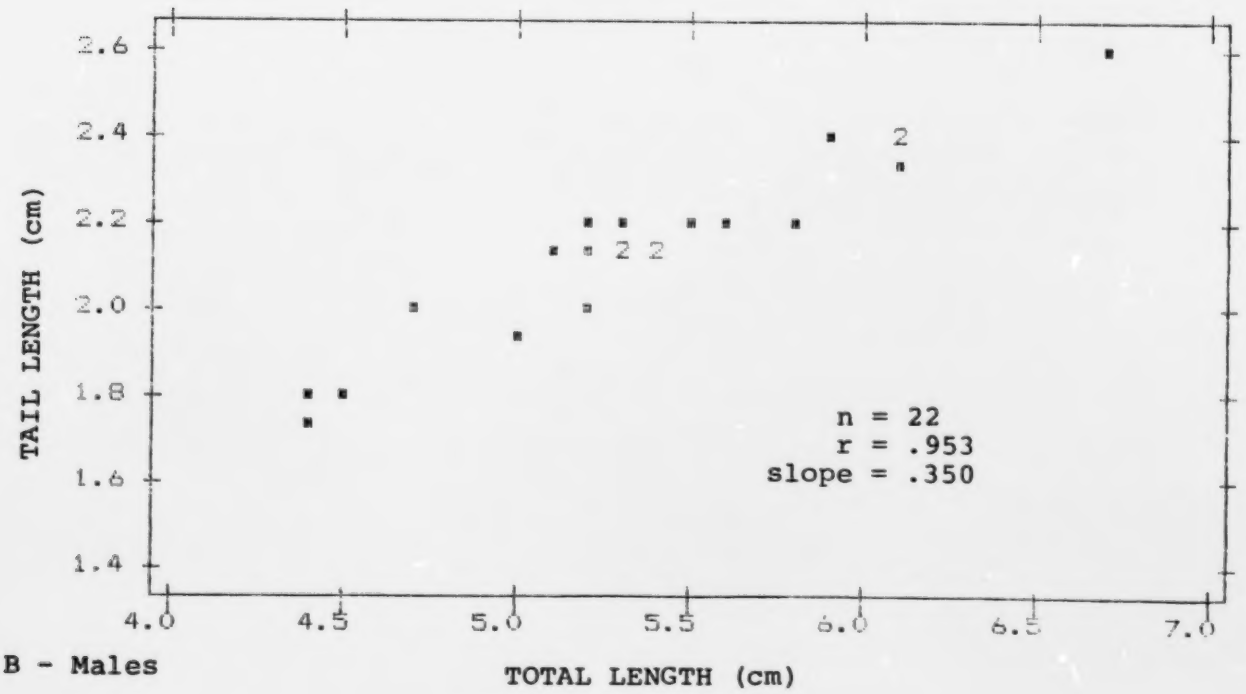


B - Males

Figure A-6 Relationships Between Tail Length and Total Length of Crayfish from the Sturgeon-Weir River.

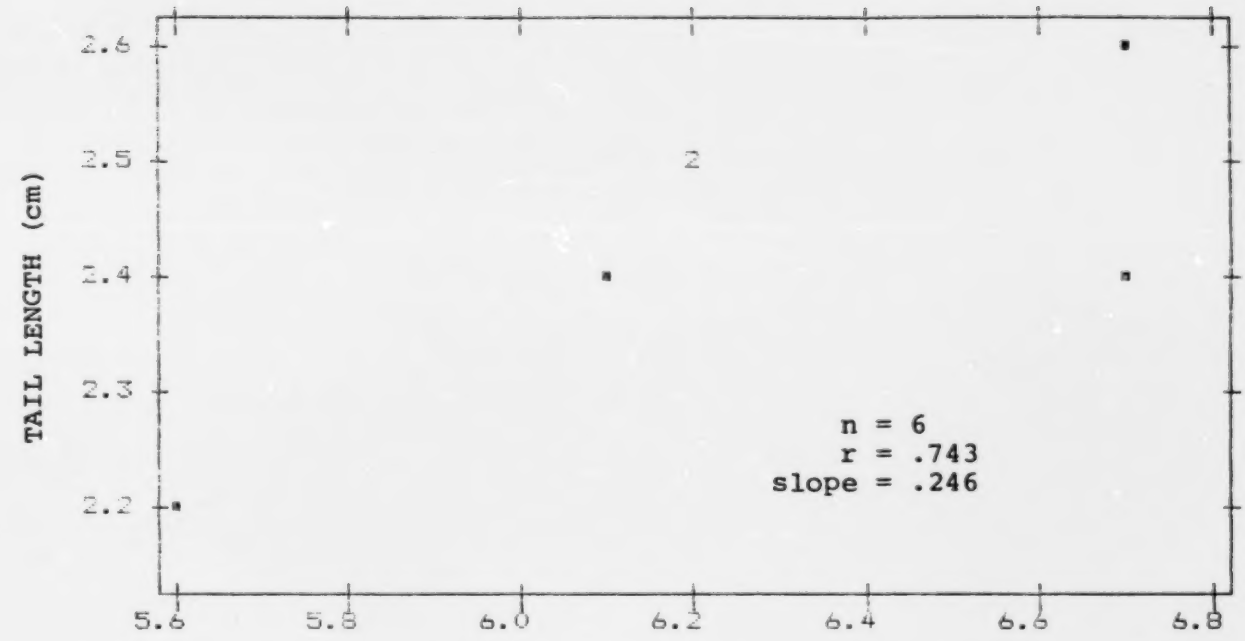


A - Females

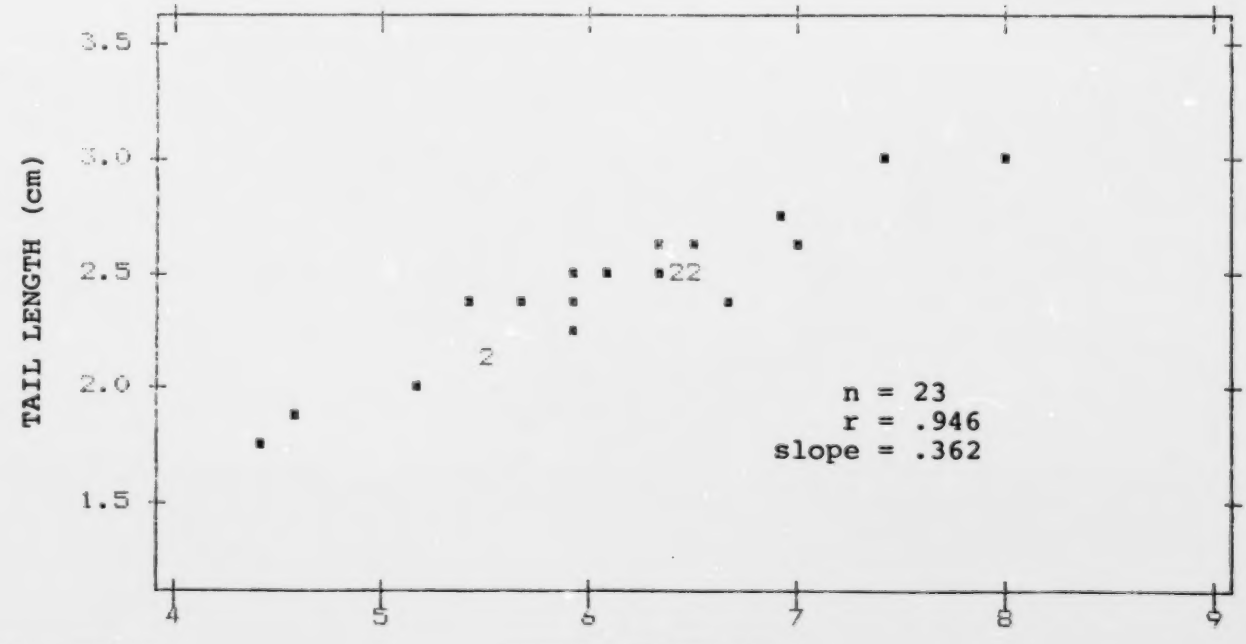


B - Males

Figure A-7 Relationships Between Tail Length and Total Length of Crayfish from Churchill Lake.

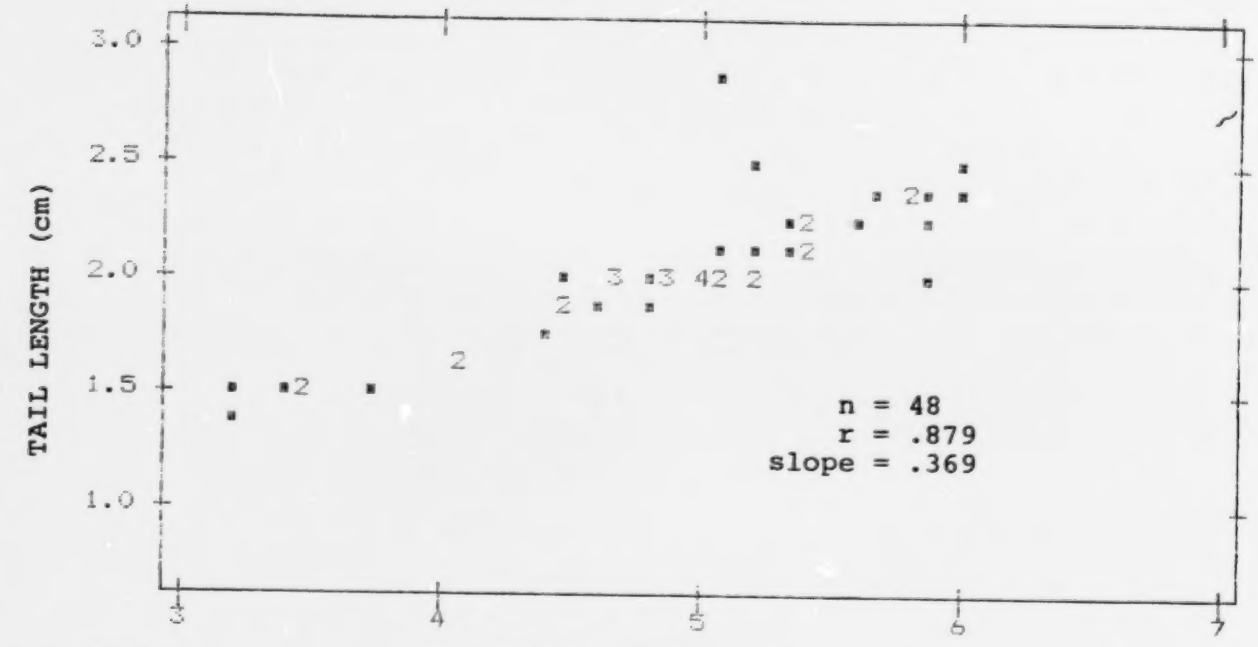


A - Females

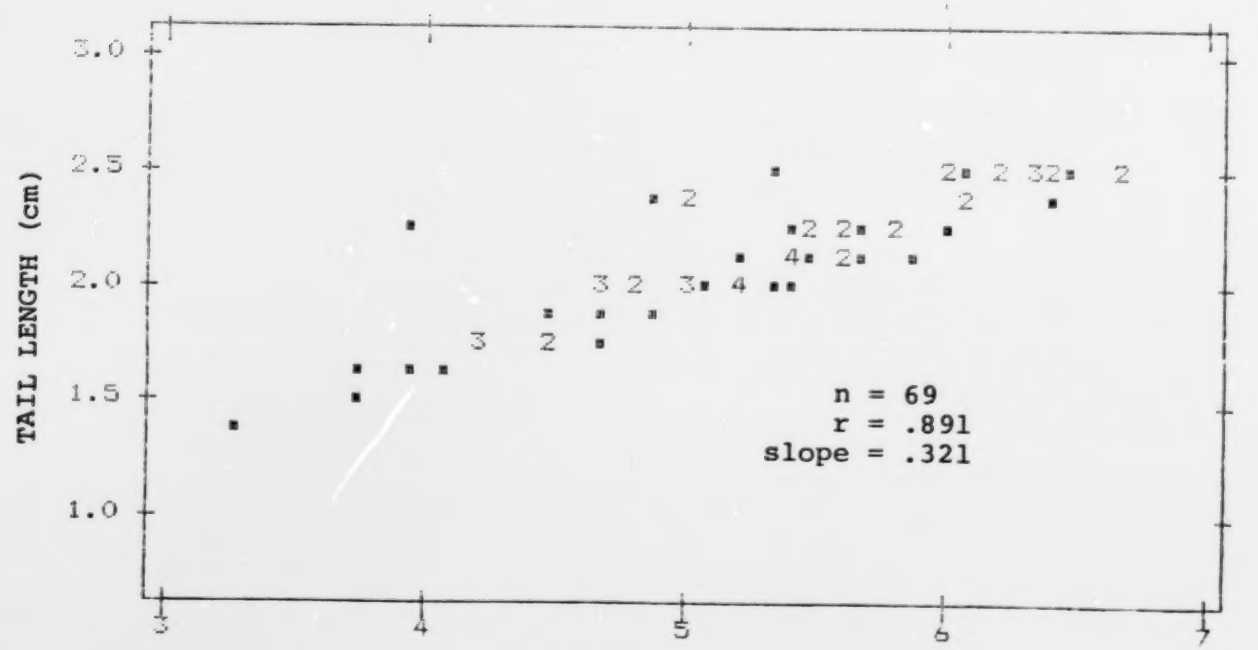


B - Males

Figure A-8 Relationships Between Tail Length and Total Length of Crayfish from Pinehouse Lake.

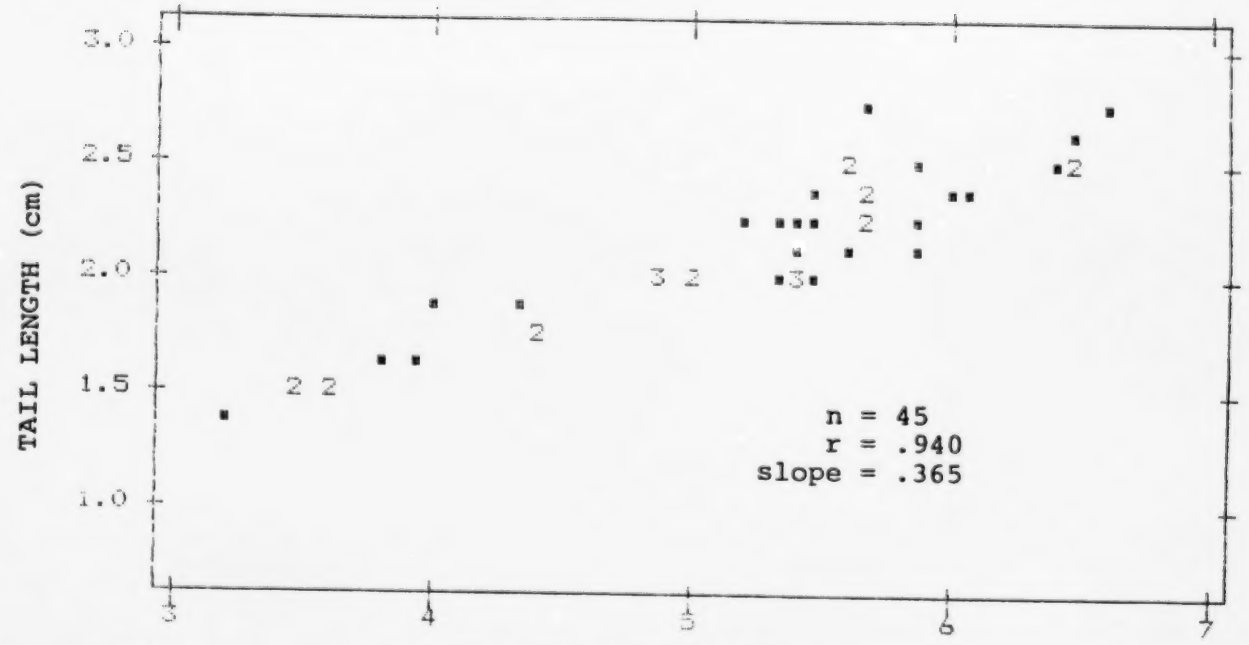


A - Females

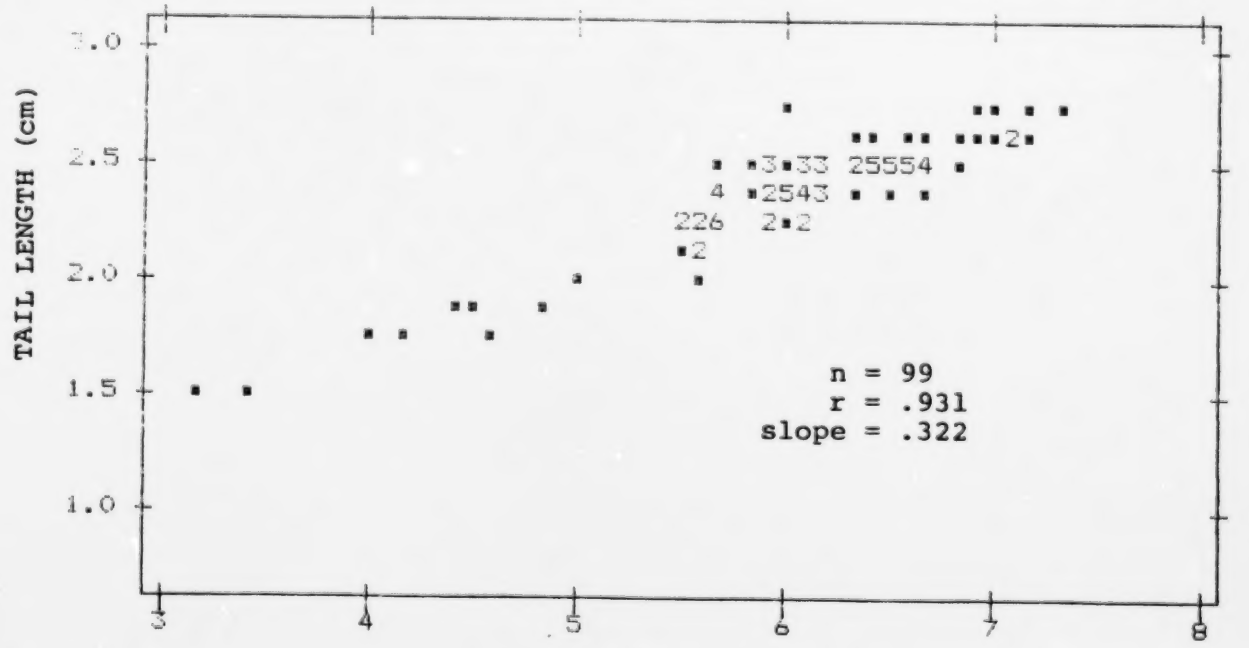


B - Males

Figure A-9 Relationships Between Tail Length and Total Length of Crayfish from Nemeiben Lake.



A - Females



B - Males

Figure A-10 Relationships Between Tail Length and Total Length of Crayfish from Otter Lake.

APPENDIX III

Appendix Table III-1. Linear Regression Analysis and Analysis of Variance of Relationships Between Crayfish Tail Lengths and Total Body Lengths.

Katepwa Lake - females

DEP VAR: TAIL N: 53 MULTIPLE R: .814 SQUARED MULTIPLE R: .662

ADJUSTED $R^2 = 1-(1-R^2)*(N-1)/DF$, WHERE N= 53, AND DF= 51: .655

VARIABLE	COEFFICIENT	STD. ERROR	STD. COEF.	TOLERANCE	T	P(2 TAIL)
CONSTANT	0.883	0.217	0.000	.	4.08	.000
TOTAL	0.271	0.027	0.814	1.00000	9.99	.000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.920	1	0.920	99.879	.000
RESIDUAL	0.470	51	0.009		

Katepwa Lake - males

DEP VAR: TAIL N: 52 MULTIPLE R: .555 SQUARED MULTIPLE R: .308

ADJUSTED $R^2 = 1-(1-R^2)*(N-1)/DF$, WHERE N= 52, AND DF= 50: .294

VARIABLE	COEFFICIENT	STD. ERROR	STD. COEF.	TOLERANCE	T	P(2 TAIL)
CONSTANT	1.069	0.407	0.000	.	2.62	.012
TOTAL	0.239	0.051	0.555	1.00000	4.72	.000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	1.135	1	1.135	22.240	.000
RESIDUAL	2.552	50	0.051		

Last Mountain Lake - females

DEP VAR: TAIL N: 136 MULTIPLE R: .946 SQUARED MULTIPLE R: .894

ADJUSTED $R^2 = 1-(1-R^2)*(N-1)/DF$, WHERE N= 136, AND DF= 134: .894

VARIABLE	COEFFICIENT	STD. ERROR	STD. COEF.	TOLERANCE	T	P(2 TAIL)
CONSTANT	0.121	0.067	0.000	.	1.81	.072
TOTAL	0.373	0.011	0.946	1.00000	33.69	.000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	27.521	1	27.521	1134.933	.000
RESIDUAL	3.249	134	0.024		

Last Mountain Lake - males

DEP VAR: TAIL N: 74 MULTIPLE R: .982 SQUARED MULTIPLE R: .964

ADJUSTED $R^2 = 1-(1-R^2)*(N-1)/DF$, WHERE N= 74, AND DF= 72: .963

VARIABLE	COEFFICIENT	STD. ERROR	STD. COEF.	TOLERANCE	T	P(2 TAIL)
CONSTANT	0.183	0.050	0.000	.	3.70	.000
TOTAL	0.350	0.008	0.982	1.00000	43.85	.000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	17.735	1	17.735	1922.721	.000
RESIDUAL	0.664	72	0.009		

Appendix Table III-1 (Continued)

Saskatchewan River - females

DEP VAR: TAIL N: 38 MULTIPLE R: .980 SQUARED MULTIPLE R: .960

ADJUSTED $R^2 = 1-(1-R^2)*(N-1)/DF$, WHERE N= 38, AND DF= 36: .959

VARIABLE	COEFFICIENT	STD. ERROR	STD. COEF.	TOLERANCE	T	P(2 TAIL)
CONSTANT	0.348	0.068	0.000	.	5.08	.000
TOTAL	0.340	0.012	0.980	1.00000	29.47	.000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	12.051	1	12.051	868.525	.000
RESIDUAL	0.500	36	0.014		

Saskatchewan River - males

DEP VAR: TAIL N: 100 MULTIPLE R: .979 SQUARED MULTIPLE R: .958

ADJUSTED $R^2 = 1-(1-R^2)*(N-1)/DF$, WHERE N= 100, AND DF= 98: .958

VARIABLE	COEFFICIENT	STD. ERROR	STD. COEF.	TOLERANCE	T	P(2 TAIL)
CONSTANT	0.232	0.049	0.000	.	4.69	.000
TOTAL	0.358	0.008	0.979	1.00000	47.52	.000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	35.921	1	35.921	2258.490	.000
RESIDUAL	1.559	98	0.016		

Sturgeon Weir River - females

DEP VAR: TAIL N: 15 MULTIPLE R: .990 SQUARED MULTIPLE R: .980

ADJUSTED $R^2 = 1-(1-R^2)*(N-1)/DF$, WHERE N= 15, AND DF= 13: .979

VARIABLE	COEFFICIENT	STD. ERROR	STD. COEF.	TOLERANCE	T	P(2 TAIL)
CONSTANT	0.106	0.071	0.000	.	1.49	.159
TOTAL	0.364	0.014	0.990	1.00000	25.28	.000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	2.330	1	2.330	638.833	.000
RESIDUAL	0.047	13	0.004		

Sturgeon Weir River - males

DEP VAR: TAIL N: 24 MULTIPLE R: .918 SQUARED MULTIPLE R: .842

ADJUSTED $R^2 = 1-(1-R^2)*(N-1)/DF$, WHERE N= 24, AND DF= 22: .835

VARIABLE	COEFFICIENT	STD. ERROR	STD. COEF.	TOLERANCE	T	P(2 TAIL)
CONSTANT	0.212	0.167	0.000	.	1.27	.218
TOTAL	0.338	0.031	0.918	1.00000	10.84	.000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	1.811	1	1.811	117.563	.000
RESIDUAL	0.339	22	0.015		

Appendix Table III-1 (Continued)

Candle Lake - females

DEP VAR: TAIL N: 5 MULTIPLE R: .876 SQUARED MULTIPLE R: .768

ADJUSTED $R^2 = 1-(1-R^2)*(N-1)/DF$, WHERE N= 5, AND DF= 3: .690

VARIABLE	COEFFICIENT	STD. ERROR	STD. COEF.	TOLERANCE	T	P(2 TAIL)
CONSTANT	-0.705	0.917	0.000	.	-.77	.498
TOTAL	0.528	0.168	0.876	1.00000	3.15	.051

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.098	1	0.098	9.922	.051
RESIDUAL	0.030	3	0.010		

Candle Lake - males

DEP VAR: TAIL N: 28 MULTIPLE R: .774 SQUARED MULTIPLE R: .598

ADJUSTED $R^2 = 1-(1-R^2)*(N-1)/DF$, WHERE N= 28, AND DF= 26: .583

VARIABLE	COEFFICIENT	STD. ERROR	STD. COEF.	TOLERANCE	T	P(2 TAIL)
CONSTANT	0.072	0.351	0.000	.	.21	.839
TOTAL	0.380	0.061	0.774	1.00000	6.22	.000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	1.011	1	1.011	38.733	.000
RESIDUAL	0.679	26	0.026		

McBride Lake - females

DEP VAR: TAIL N: 102 MULTIPLE R: .974 SQUARED MULTIPLE R: .948

ADJUSTED $R^2 = 1-(1-R^2)*(N-1)/DF$, WHERE N= 102, AND DF= 100: .948

VARIABLE	COEFFICIENT	STD. ERROR	STD. COEF.	TOLERANCE	T	P(2 TAIL)
CONSTANT	0.131	0.041	0.000	.	3.21	.002
TOTAL	0.364	0.009	0.974	1.00000	42.76	.000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	20.150	1	20.150	1828.439	.000
RESIDUAL	1.102	100	0.011		

McBride Lake - males

DEP VAR: TAIL N: 120 MULTIPLE R: .963 SQUARED MULTIPLE R: .928

ADJUSTED $R^2 = 1-(1-R^2)*(N-1)/DF$, WHERE N= 120, AND DF= 118: .927

VARIABLE	COEFFICIENT	STD. ERROR	STD. COEF.	TOLERANCE	T	P(2 TAIL)
CONSTANT	0.230	0.048	0.000	.	4.77	.000
TOTAL	0.340	0.009	0.963	1.00000	38.92	.000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	24.714	1	24.714	1515.110	.000
RESIDUAL	1.925	118	0.016		

Appendix Table III-1 (Continued)

Nemeiben Lake - females

DEP VAR: TAIL N: 48 MULTIPLE R: .879 SQUARED MULTIPLE R: .773

ADJUSTED $R^2 = 1-(1-R^2)*(N-1)/DF$, WHERE N= 48, AND DF= 46: .768

VARIABLE	COEFFICIENT	STD. ERROR	STD. COEF.	TOLERANCE	T	P(2 TAIL)
CONSTANT	0.147	0.147	0.000	.	1.00	.321
TOTAL	0.369	0.030	0.879	1.00000	12.51	.000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	3.504	1	3.504	156.446	.000
RESIDUAL	1.030	46	0.022		

Nemeiben Lake - males

DEP VAR: TAIL N: 69 MULTIPLE R: .891 SQUARED MULTIPLE R: .795

ADJUSTED $R^2 = 1-(1-R^2)*(N-1)/DF$, WHERE N= 69, AND DF= 67: .792

VARIABLE	COEFFICIENT	STD. ERROR	STD. COEF.	TOLERANCE	T	P(2 TAIL)
CONSTANT	0.381	0.107	0.000	.	3.57	.001
TOTAL	0.321	0.020	0.891	1.00000	16.11	.000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	4.317	1	4.317	259.423	.000
RESIDUAL	1.115	67	0.017		

Otter Lake - females

DEP VAR: TAIL N: 45 MULTIPLE R: .940 SQUARED MULTIPLE R: .884

ADJUSTED $R^2 = 1-(1-R^2)*(N-1)/DF$, WHERE N= 45, AND DF= 43: .881

VARIABLE	COEFFICIENT	STD. ERROR	STD. COEF.	TOLERANCE	T	P(2 TAIL)
CONSTANT	0.169	0.106	0.000	.	1.59	.120
TOTAL	0.365	0.020	0.940	1.00000	18.09	.000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	4.808	1	4.808	327.083	.000
RESIDUAL	0.632	43	0.015		

Otter Lake - males

DEP VAR: TAIL N: 99 MULTIPLE R: .931 SQUARED MULTIPLE R: .866

ADJUSTED $R^2 = 1-(1-R^2)*(N-1)/DF$, WHERE N= 99, AND DF= 97: .865

VARIABLE	COEFFICIENT	STD. ERROR	STD. COEF.	TOLERANCE	T	P(2 TAIL)
CONSTANT	0.378	0.078	0.000	.	4.82	.000
TOTAL	0.322	0.013	0.931	1.00000	25.05	.000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	5.584	1	5.584	627.479	.000
RESIDUAL	0.863	97	0.009		

Appendix Table III-1 (Continued)

Churchill Lake - females

DEP VAR: TAIL N: 14 MULTIPLE R: .920 SQUARED MULTIPLE R: .847

ADJUSTED $R^2 = 1-(1-R^2)*(N-1)/DF$, WHERE N= 14, AND DF= 12: .834

VARIABLE	COEFFICIENT	STD. ERROR	STD. COEF.	TOLERANCE	T	P(2 TAIL)
CONSTANT	0.029	0.272	0.000	.	.10	.918
TOTAL	0.400	0.049	0.920	1.00000	8.14	.000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	1.040	1	1.040	66.182	.000
RESIDUAL	0.189	12	0.016		

Churchill Lake - males

DEP VAR: TAIL N: 22 MULTIPLE R: .953 SQUARED MULTIPLE R: .908

ADJUSTED $R^2 = 1-(1-R^2)*(N-1)/DF$, WHERE N= 22, AND DF= 20: .903

VARIABLE	COEFFICIENT	STD. ERROR	STD. COEF.	TOLERANCE	T	P(2 TAIL)
CONSTANT	0.249	0.135	0.000	.	1.85	.079
TOTAL	0.350	0.025	0.953	1.00000	14.03	.000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.897	1	0.897	196.945	.000
RESIDUAL	0.091	20	0.005		

Pinehouse Lake - females

DEP VAR: TAIL N: 6 MULTIPLE R: .743 SQUARED MULTIPLE R: .553

ADJUSTED $R^2 = 1-(1-R^2)*(N-1)/DF$, WHERE N= 6, AND DF= 4: .441

VARIABLE	COEFFICIENT	STD. ERROR	STD. COEF.	TOLERANCE	T	P(2 TAIL)
CONSTANT	0.898	0.692	0.000	.	1.30	.264
TOTAL	0.246	0.110	0.743	1.00000	2.22	.090

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.052	1	0.052	4.941	.090
RESIDUAL	0.042	4	0.010		

Pinehouse Lake - males

DEP VAR: TAIL N: 23 MULTIPLE R: .946 SQUARED MULTIPLE R: .894

ADJUSTED $R^2 = 1-(1-R^2)*(N-1)/DF$, WHERE N= 23, AND DF= 21: .889

VARIABLE	COEFFICIENT	STD. ERROR	STD. COEF.	TOLERANCE	T	P(2 TAIL)
CONSTANT	0.165	0.168	0.000	.	.99	.335
TOTAL	0.362	0.027	0.946	1.00000	13.33	.000

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	1.997	1	1.997	177.822	.000
RESIDUAL	0.236	21	0.011		